VERIFICATION OF A TRANSLATION

I, Tetsuo AKIYOSHI, of 5th Floor, Shintoshicenter Bldg., 24-1, Tsurumaki 1-chome, Tama-shi, Tokyo 206-0034 Japan, declare that I am well acquainted with both the Japanese and English languages, and that the attached is an accurate translation, to the best of my knowledge and ability, of the Japanese language Patent Application No. JP2002-206799 filed on July 16, 2002.

Signature ________________ Date Nov. 16, 2007

[Name of Document]	PATENT APPLICATION
[Reference Number]	2931040016
[Filing Date]	July 16, 2002
[To]	Commissioner, Patent Office
[International Patent Classification]	H04L 27/32
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[Prepayment Register Number]	011305	
[Amount of Payment]	¥21,000	
[List of Items Submitted]		
[Name of Item]	Specification	1
[Name of Item]	Drawing	1
[Name of Item]	Abstract	1
[Number of General Power of Attorney]	9809938	

[Name of Document] SPECIFICATION

[Title of the Invention] COMMUNICATION METHOD, AND TRANSMITTING APPARATUS AND RECEIVING APPARATUS USING THAT COMMUNICATION METHOD

[Claims]

[Claim 1]

A communication method of transmitting a modulated signal with a plurality of carriers, comprising:

a step of transmitting one modulated signal of a communication mode by a first carrier; and

a step of multiplexing and transmitting a plurality of modulated signals of the communication mode by a second carrier.

[Claim 2]

A communication method comprising:

a step of multiplexing and transmitting a plurality of modulated signals of a communication mode as a first frequency; and

a step of transmitting one modulated signal of the communication mode as a second frequency.

[Claim 3]

A communication method comprising:

a step of transmitting one modulated signal of a communication mode by a first time; and

a step of multiplexing and transmitting a plurality of modulated signals of the communication mode by a second time.

[Claim 4]

A communication method of transmitting a modulated signal with a plurality of carriers, comprising:

a step of transmitting one modulated signal of a communication mode by a first carrier; and

a step of multiplexing and transmitting a plurality of modulated signals of the communication mode by a second carrier:

wherein information is transmitted by the first carrier or the second carrier in accordance with communication environment.

[Claim 5]

A communication method comprising:

a step of multiplexing and transmitting a plurality of modulated signals of a communication mode as a first frequency; and

a step of transmitting one modulated signal of the communication mode as a second frequency:

wherein information is transmitted by the first frequency or the second frequency in accordance with a communication environment.

[Claim 6]

A communication method comprising:

a step of transmitting one modulated signal of a communication mode by a first time; and

a step of multiplexing and transmitting a plurality of modulated signals of the communication mode by a second time:

wherein information is transmitted by the first time or the second time in accordance with communication environment.

[Claim 7]

A communication method of transmitting a modulated signal with a plurality of carriers, comprising:

a step of transmitting one modulated signal of a communication mode by a first carrier; and

a step of multiplexing and transmitting a plurality of modulated signals of the communication mode by a second carrier:

wherein important information is transmitted by the first carrier.

[Claim 8]

A communication method comprising:

a step of multiplexing and transmitting a plurality of modulated signals of a communication mode as a first frequency; and

a step of transmitting one modulated signal of the communication mode as a second frequency:

wherein important information is transmitted by the second frequency.

[Claim 9]

A communication method comprising:

a step of transmitting one modulated signal of a communication mode by a first time; and

a step of multiplexing and transmitting a plurality of modulated signals of the communication mode by a second time:

wherein important information is transmitted by the first time.

[Claim 10]

A communication method of transmitting a modulated signal with a plurality of carriers, comprising:

a step of transmitting one modulated signal of a communication mode by a first carrier;

a step of multiplexing and transmitting a plurality of modulated signals of the communication mode by a second carrier; and

a step of transmitting differential information of information, which is transmitted by the first carrier, by the second carrier.

[Claim 11]

A communication method comprising:

a step of multiplexing and transmitting a plurality of modulated signals of a communication mode as a first frequency;

a step of transmitting one modulated signal of a communication mode as a first frequency; and

a step of transmitting differential information of information, which is transmitted by the second frequency, by the first frequency.

[Claim 12]

A communication method comprising:

a step of transmitting one modulated signal of a communication mode by a first time;

a step of multiplexing and transmitting a plurality of modulated signals of the communication mode by a second time; and

a step of transmitting differential information of information, which is transmitted by the first time, by the second time.

[Claim 13]

The communication method according to anyone of Claims 1, 4, 7, and 10, wherein the communication mode of transmitting the modulated signal with the plurality of carriers is OFDM (Orthogonal Frequency Division Multiplex).

[Claim 14]

A transmitting apparatus comprising:

a plurality of transmission sections that generate a modulated signal including a plurality of carriers of a communication mode and transmit the modulated signal from an antenna:

wherein the modulated signal is transmitted in accordance with the

communication method according to anyone of Claims 1, 4, 7, 10, and 13.

[Claim 15]

A transmitting apparatus comprising:

a plurality of transmission sections that generate a modulated signal of a communication mode by a first frequency and transmit the modulated signal from an antenna; and

a transmission section that generates a modulated signal of the communication mode by a second frequency and transmits the modulated signal from an antenna:

wherein the modulated signal is transmitted in accordance with the communication method according to anyone of Claims 2, 5, 8, and 11.

[Claim 16]

A transmitting apparatus comprising:

a plurality of transmission sections that generate a modulated signal of a communication mode and transmit the modulated signal from an antenna:

wherein the modulated signal is transmitted in accordance with the communication method according to anyone of Claims 3, 6, 9, and 12.

[Claim 17]

A receiving apparatus comprising:

a demodulation section that receives a modulated signal of the communication method according to anyone of Claims 1, 4, 7, 10, and 13 by a plurality of antennas and demodulates one modulated signal of the communication mode of the first carrier; and

a demodulation section that separates a multiplexed and modulated signal of the second carrier and demodulates each separated modulated

signal.

[Claim 18]

A receiving apparatus comprising:

a demodulation section that receives a multiplexed modulated signal of a first frequency among demodulated signals of the communication method according to anyone of Claims 2, 5, 8, and 11 by a plurality of antennas, separates the multiplexed modulated signal, and demodulates each separated modulated signal; and

a demodulation section that receives a modulated signal of a second frequency and demodulates the modulated signal.

[Claim 19]

A receiving apparatus comprising:

a demodulation section that receives a modulated signal of the communication method according to anyone of Claims 3, 6, 9, and 12 by a plurality of antennas and demodulates a signal of a first time in which one modulated signal of a communication mode exists; and

a demodulation section that separates a signal of a second time in which a multiplexed modulated signal of a communication mode exits and demodulates each separated modulated signal.

[Claim 20]

The communication method according to Claim 4, wherein information is transmitted by one modulated signal of the communication mode of the first carrier at the start of communication.

[Claim 21]

The communication method according to Claim 5, wherein information is transmitted by the second frequency that transmits one modulated signal of the communication mode at the start of

communication.

[Claim 22]

The communication method according to Claim 6, wherein information is transmitted by one modulated signal of the communication mode of the first time at the start of communication.

[Claim 23]

The communication method according to Claim 4, further comprising:

a step of transmitting an estimation symbol by a transmitting apparatus at the start of communication;

a step of estimating radio wave propagation environment by means of the estimation symbol;

a step of transmitting information related to communication method determination; and

a step of determining whether information is transmitted by the first carrier or the second carrier based on the information related to the communication method determination.

[Claim 24]

The communication method according to Claim 5, further comprising:

a step of transmitting an estimation symbol by a transmitting apparatus at the start of communication;

a step of estimating radio wave propagation environment by means of the estimation symbol;

a step of transmitting information related to communication method determination; and

a step of determining whether information is transmitted by the

first frequency or the second frequency based on the information related to the communication method determination.

[Claim 25]

The communication method according to Claim 6, further comprising:

a step of transmitting an estimation symbol by a transmitting apparatus at the start of communication;

a step of estimating a radio wave propagation environment by means of the estimation symbol;

a step of transmitting information related to communication method determination; and

a step of determining whether information is transmitted by the first time or the second time based on the information related to the communication method determination.

[Claim 26]

The transmitting apparatus for transmitting information by one modulated signal of the communication mode of the first carrier at the start of communication by using the communication method according to Claim 4.

[Claim 27]

The transmitting apparatus for transmitting information by the second frequency that transmits one modulated signal of the communication mode at the start of communication by using the communication method according to Claim 5.

[Claim 28]

The transmitting apparatus for transmitting information by one modulated signal of the communication mode of the first time at the

start of communication by using the communication method according to Claim 6.

[Claim 29]

The transmitting apparatus for transmitting an estimation symbol at the start of communication by using the communication method according to anyone of Claims 23 to 25.

[Claim 30]

A radio for receiving the estimation symbol transmitted from the transmitting apparatus according to Claim 29 and for generating and transmitting information related to communication method determination.

[Claim 31]

A communication method of transmitting a modulated signal of a plurality of channels from a plurality of antennas to the same frequency band, wherein after a multiplexed signal is separated into a modulated signal of each channel by a pilot symbol used to separate the multiplexed signal, a pilot signal for demodulating the modulated signal of each channel is inserted.

[Claim 32]

The communication method according to Claim 31, wherein the pilot symbol used to separate the multiplexed signal is transmitted without being multiplexed, and the pilot signal for demodulating the modulated signal of each channel is multiplexed.

[Claim 33]

The communication method according to Claim 31 or Claim 32, wherein the pilot signal is inserted into only one channel.

[Claim 34]

A communication method of transmitting a modulated signal of a plurality of channels from a plurality of antennas to the same frequency band, wherein deferential encoding is performed between a modulated signal of a first channel and a modulated signal of a second channel.

[Claim 35]

The communication method according to Claim 34, wherein a modulation mode for the modulated signals of the first channel and the second channel is PSK (Phase Shift Keying) modulation.

[Claim 36]

A communication method of transmitting a modulated signal of a plurality of channels from a plurality of antennas to the same frequency band, wherein with reference to a signal point of the modulated signal of the first channel, a signal point of the modulated signal of the second channel is arranged.

[Claim 37]

A communication method of transmitting a modulated signal of a plurality of channels from a plurality of antennas to the same frequency band, wherein the modulated signal of the first channel for the modulated signal of the second channel is a pilot signal.

[Claim 38]

The communication method according to Claim 37, wherein the modulated signal of the first channel is always transmitted.

[Claim 39]

The communication method according to Claim 37 or Claim 38, wherein control information is transmitted by the modulated signal of the first channel.

[Claim 40]

The communication method according to anyone of Claims 36 to 39, wherein the modulated signal of the first channel is a PSK modulation mode.

[Claim 41]

A transmitting apparatus for transmitting the modulated signal of the communication method according to Claim 31 or Claim 32, comprising:

a pilot symbol signal generation section that separates a multiplexed signal; and

a signal generation section that generates a modulated signal into which a pilot symbol used to demodulate the modulated signal is inserted.

[Claim 42]

A transmitting apparatus for transmitting the modulated signal of the communication method according to Claim 33, comprising:

a modulated signal generation section that corresponds to each channel:

wherein a pilot symbol is inserted into only one modulated signal generation section among a plurality of modulated signal generation sections.

[Claim 43]

A transmitting apparatus for transmitting the modulated signal of the communication method according to Claim 34 or Claim 35, comprising:

a differential encoding section that differentially encodes signals of the first channel and the second channel.

[Claim 44]

A transmitting apparatus for transmitting the modulated signal of the communication method according to Claim 36, comprising:

an encoding section that arranges a signal point of the demodulated signal of the second channel with reference to the signal point of the modulated signal of the first channel.

[Claim 45]

A transmitting apparatus for transmitting the modulated signal of the communication method according to Claim 37, comprising:

a signal generation section that generates a modulated signal as a pilot channel.

[Claim 46]

A receiving apparatus for receiving the modulated signal of the communication method according to Claim 31 or Claim 32, comprising:

a separation section that separates a multiplexed signal by using a pilot symbol used to separate the multiplexed signal; and

a demodulation section that receives a modulated signal of a separated channel as input, demodulates the modulated signal by the pilot symbol for demodulation, and outputs a received digital signal.

[Claim 47]

A receiving apparatus for receiving the modulated signal of the communication method according to Claim 33, comprising:

a first demodulation section that receives a modulated signal of a channel into which a pilot symbol is inserted and a modulated signal of the first channel as input and that demodulates the modulated signal of the first channel by using the pilot symbol inserted into the modulated signal of the channel into which the pilot symbol is inserted.

[Claim 48]

A receiving apparatus for receiving the modulated signal of the communication method according to Claim 34 or Claim 35, comprising:

a differential wave detection section that receives a modulated signal of the first channel and a modulated signal of the second channel as input, performs deferential wave detection, and outputs a received digital signal.

[Claim 49]

A receiving apparatus for receiving the modulated signal of the communication method according to Claim 36 or Claim 37, comprising:

a demodulation section that receives a modulated signal of the first channel and a modulated signal of the second channel as input and that demodulates the modulated signal of the second channel based on the modulated signal of the first channel.

[Claim 50]

A receiving apparatus for receiving the modulated signal of the communication method according to anyone of Claims 31, 32, 33, and 37, comprising:

a channel distortion estimation section that estimates a channel distortion by using the pilot symbol.

[Claim 51]

A receiving apparatus for receiving the modulated signal of the communication method according to anyone of Claims 31, 32, 33, and 37, comprising:

a frequency offset estimation section that estimates a frequency offset by using the pilot symbol.

[Claim 52]

In a transmitting method of transmitting a modulated signal of a

plurality of channels from a plurality of antennas in the same frequency band, a transmitting apparatus comprising:

a frequency source for a transmission base band; and

a frequency source for a radio section.

[Claim 53]

In a transmitting method of transmitting a modulated signal of a plurality of channels from a plurality of antennas in the same frequency band, a transmitting apparatus comprising:

a frequency source for a reception base band; and

a frequency source for a radio section.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to a communication method, and a transmitting apparatus and receiving apparatus that use that communication method.

[0002]

[Description of the Related Art]

FIG. 38 shows one example of the configuration of a conventional radio transmitting apparatus and receiving apparatus. A modulated signal generation section 02 receives a transmit digital signal 01 as input, and outputs a modulated signal 03.

[0003]

A radio section 04 receives a modulated signal as input, and outputs a transmit signal 05.

[0004]

A power amplification section 06 receives transmit signal 05 as input, amplifies transmit signal 05 and outputs amplified transmit signal 07, and then amplified transmit signal 07 is output as a radio wave from an antenna 08.

[0005]

A radio section 11 receives a received signal 10 received from an antenna 09 as input, and outputs a received quadrature baseband signal 12.

[0006]

A demodulation section 13 receives received quadrature baseband signal 12 as input, and outputs a received digital signal 14.

[0007]

Thus, in a conventional apparatus, a plurality of modulated signals is not multiplexed.

[0008]

[Problems to be Solved by the Invention]

According to the present invention, the data transmission speed can be improved by having a transmitting apparatus multiplex and transmit a plurality of modulated signals, and a receiving apparatus separate and demodulate the transmitted multiplexed modulated signals. Also, by configuring in accordance with either a method whereby one modulated signal of a communication system is transmitted, or a method whereby a plurality of modulated signals of a communication system are multiplexed and transmitted, by frequency and time, it is possible for a communicating party to obtain information accurately by transmitting information of high importance by means of a method whereby one modulated signal of a communication system is transmitted. Moreover,

by performing communication by frequency or time of a method whereby one modulated signal of a communication system is transmitted, and by frequency or time of a method whereby a plurality of modulated signals of a communication system are multiplexed and transmitted, according to the communication conditions, it is possible to make information transmission speed and received data quality compatible.

[0009]

Also, when a plurality of modulated signals are multiplexed and transmitted, and the transmitted multiplexed signals are separated and demodulated by the receiving apparatus, it is necessary to perform high-precision separation and demodulation.

[0010]

[Means for Solving the Problems]

The present invention enables compatibility between data transmission speed and transmission quality to be achieved, by configuring a frame for transmitting a plurality of modulated signals from a plurality of antennas and a frame for transmitting a modulated signal from one antenna. Then, there are the frame for transmitting a plurality of modulated signals from a plurality of antennas and the frame for transmitting a modulated signal from one antenna, and important information is transmitted by the modulated signal transmitted from one antenna, whereby the data quality can be ensured in the receiving apparatus. Also, the information of the radio wave propagation environment estimated by the receiving apparatus and the control information, like communication request information, are transmitted, and, based on that information, by appropriately selecting

whether data is transmitted by the frame for transmitting a plurality of modulated signals from a plurality of antennas or the frame for transmitting a modulated signal from one antenna, whereby it is possible for the receiving apparatus to make information transmission speed and transmission quality compatible.

[0011]

Also, when a plurality of modulated signal is multiplexed and transmitted, a pilot symbol for separation and a pilot symbol for demodulation are inserted, whereby separation and demodulation can be performed accurately.

[0012]

Then, encoding is performed among channels and a pilot symbol is shared among channels, whereby pilot symbols can be reduced and the data transmission speed is improved.

[0013]

[Description of the Embodiments]

The communication method of the present invention is a communication method of transmitting a modulated signal with a plurality of carriers, in which one modulated signal of a communication mode is transmitted by a first carrier, and a plurality of modulated signals of the communication mode is multiplexed and transmitted by a second carrier.

[0014]

The communication method of the present invention is a communication method, in which a plurality of modulated signals of a communication mode is multiplexed and transmitted by a first frequency, and one modulated signal of the communication mode is

transmitted by a second frequency.

[0015]

A communication method of the present invention is a communication method in which one modulated signal of a communication mode is transmitted by a first time, and a plurality of modulated signals of the communication mode is multiplexed and transmitted by a second time.

[0016]

Accordingly, important information (the radio wave propagation environment information estimated by the receiving apparatus, the communication request information, and the like) is transmitted by one modulated signal of the commutation mode, whereby the system operates stably.

[0017]

A communication method of the present invention is a communication method of transmitting a modulated signal with a plurality of carriers, in which there is a communication apparatus for transmitting one modulated signal of a communication mode by a first carrier and multiplexing and transmitting a plurality of modulated signals of the communication mode by a second carrier, and information is transmitted to a communication party by the first carrier or the second carrier in accordance with communication environment.

[0018]

A communication method of the present invention is a communication method, in which there are a first frequency to multiplex and transmit a plurality of modulated signals of a communication modeand second frequency to transmit one modulated

signal of the communication mode, there is a communication apparatus for transmitting a modulated signal, and information is transmitted to a communication party by the first frequency or the second frequency in accordance with a communication environment.

[0019]

A communication method of the present invention is a communication method, in which there is a communication apparatus for transmitting one modulated signal of a communication mode by a first time and multiplexing and transmitting a plurality of modulated signals of the communication mode by a second time, and information is transmitted to a communication party by the first time or the second time in accordance with a communication environment.

[0020]

Therefore, the data transmission by the plurality of channels and the data transmission by one channel are adaptively switched, whereby the data transmission speed and the transmission quality can be compatible.

[0021]

A communication method of the present invention is a communication method of transmitting a modulated signal with a plurality of carriers, in which one modulated signal of a communication mode is transmitted by a first carrier, a plurality of modulated signals of the communication mode is multiplexed and transmitted by a second carrier, and important information is transmitted by the first carrier that transmits one modulated signal of the communication mode.

[0022]

A communication method of the present invention is a

communication method, in which there are a first frequency to multiplex and transmit a plurality of modulated signals of a communication mode and a second frequency to transmit one modulated signal of a communication mode , and important information is transmitted by the second frequency that transmits one modulated signal of the communication mode.

[0023]

A communication method of the present invention is a communication method, in which one modulated signal of a communication mode is transmitted by a first time, a plurality of modulated signals of the communication mode is multiplexed and transmitted by a second time, and important information is transmitted by the first time that transmits one modulated signal of the communication mode.

[0024]

Therefore, the important information is transmitted by one modulated signal of the communication mode, whereby the system operates stably.

[0025]

A communication method of the present invention is a communication method of transmitting a modulated signal with a plurality of carriers, in which one modulated signal of a communication mode is transmitted by a first carrier, a plurality of modulated signals of a communication mode is multiplexed and transmitted by a second carrier that transmits one modulated signal of the communication mode, and differential information of information, which is transmitted by the first carrier, is transmitted by the second carrier that multiplexes and

transmits a plurality of modulated signals of the communication mode.

[0026]

A communication method of the present invention is a communication method, in which there is a first frequency to multiplex and transmit a plurality of modulated signals of a communication modeand a second frequency to transmit one modulated signal of a communication mode , and differential information of information, which is transmitted by the second frequency that transmits one modulated signal of the communication mode, is transmitted by the first frequency that multiplexes and transmits a plurality of modulated signals of the communication mode.

[0027]

A communication method of the present invention is a communication method, in which one modulated signal of a communication mode is transmitted by a first time, a plurality of modulated signals of the communication mode is multiplexed and transmitted by a second time, and differential information of information, which is transmitted by the first time that transmits one modulated signal of the communication mode, is transmitted by the second time that multiplexes and transmits a plurality of modulated signals of the communication mode.

[0028]

In this way, the differential information is transmitted, whereby the flexible system that can perform a helical data transmission can be configured.

[0029]

The communication method of the present invention is a

transmission method according to anyone of Claims 1, 4, 7, and 10, wherein the communication mode of transmitting the modulated signal with the plurality of carriers is OFDM.

[0030]

Therefore, since a frame can be configured on the frequency-time axes, a flexible system can be configured.

[0031]

A transmitting apparatus of the present invention is a transmitting apparatus that is provided with a plurality of transmission sections that generate a modulated signal including a plurality of carriers of a communication mode and transmit the modulated signal from an antenna, and the modulated signal is transmitted in accordance with the communication method according to anyone of Claims 1, 4, 7, 10, and 13.

[0032]

A transmitting apparatus of the present invention is a transmitting apparatus that is provided with a plurality of transmission sections that generate a modulated signal of a communication mode by a first frequency and transmit the modulated signal from an antenna and a transmission section that generates a modulated signal of the communication mode by a second frequency and transmits the modulated signal from an antenna, wherein the modulated signal is transmitted in accordance with the communication method according to anyone of Claims 2, 5, 8, and 11.

[0033]

A transmitting apparatus of the present invention is a transmitting apparatus that is provided with a plurality of transmission sections that

generate a modulated signal of a communication mode and transmit the modulated signal from an antenna, wherein the modulated signal is transmitted in accordance with the communication method according to anyone of Claims 3, 6, 9, and 12.

[0034]

A receiving apparatus of the present invention is a receiving apparatus that is provided with a demodulation section that receives a modulated signal of the communication method according to anyone of Claims 1, 4, 7, 10, and 13 by a plurality of antennas and demodulates one modulated signal of the communication mode of the first carrier, and a demodulation section that separates a multiplexed and modulated signal of the second carrier and demodulates each separated modulated signal.

[0035]

A receiving apparatus of the present invention is a receiving apparatus that is provided with a demodulation section that receives a modulated signal multiplexed by the first frequency among demodulated signals of the communication method according to anyone of Claims 2, 5, 8, and 11 by a plurality of antennas, separates the multiplexed modulated signal, and demodulates each separated modulated signal and a demodulation section that receives a modulated signal of the second frequency and demodulates the modulated signal.

[0036]

A receiving apparatus of the present invention is a receiving apparatus that is provided with a demodulation section that receives a modulated signal of the communication method according to anyone of Claims 3, 6, 9, and 12 by a plurality of antennas and demodulates a

signal of a first time in which one modulated signal of a communication mode exists and a demodulation section that separates a signal of a second time in which a multiplexed modulated signal of a communication mode exits and demodulates each separated modulated signal.

[0037]

According to this arrangement, the data transmission speed and the quality can be compatible.

[0038]

A communication method of the present invention is a communication method according to Claim 4, wherein information is transmitted to a communication party by one modulated signal of the communication mode of the first carrier at the start of communication.

[0039]

A communication method of the present invention is the communication method according to Claim 5, wherein information is transmitted to a communication party by the second frequency that transmits one modulated signal of the communication mode at the start of communication.

[0040]

A communication method of the present invention is the communication method according to Claim 6, wherein information is transmitted to a communication party by one modulated signal of the communication mode of the first time at the start of communication.

[0041]

A communication method of the present invention is the communication method according to Claim 4, in which a first apparatus

transmits an estimation symbol at the start of communication, a communication party estimates a radio wave propagation environment by the estimation symbol and transmits information related to a communication method determination , and the first apparatus determines whether information is transmitted by the first carrier or the second carrier based on the information related to the communication method determination.

[0042]

A communication method of the present invention is the communication method according to Claim 5, in which a first apparatus transmits an estimation symbol at the start of communication, a communication party estimates a radio wave propagation environment by the estimation symbol and transmits information related to a communication method determination , and the first apparatus determines whether information is transmitted by the first frequency or the second frequency based on the information related to the communication method determination.

[0043]

A communication method of the present invention is the communication method according to Claim 6, in which a first apparatus transmits an estimation symbol by a transmitting apparatus at the start of communication, a communication party estimates a radio wave propagation environment by the estimation symbol and transmits information related to communication method determination , and the first apparatus determines whether information is transmitted by the first time or the second time based on the information related to the communication method determination.

[0044]

A transmitting apparatus of the present invention is the transmitting apparatus for transmitting information to a communication party by one modulated signal of the communication mode of the first carrier at the start of communication by the communication method according to Claim 4.

[0045]

A transmitting apparatus of the present invention is the transmitting apparatus for transmitting information by the second frequency that transmits one modulated signal of the communication mode to a communication party at the start of communication by the communication method according to Claim 5.

[0046]

A transmitting apparatus of the present invention is the transmitting apparatus for transmitting information to a communication party by one modulated signal of the communication mode of the first time at the start of communication by the communication method according to Claim 6.

[0047]

A transmitting apparatus of the present invention is the transmitting apparatus for transmitting an estimation symbol at the start of communication by the communication method according to anyone of Claims 23 to 25.

[0048]

A radio of the present invention is a radio for receiving the estimation symbol transmitted from the transmitting apparatus according to Claim 29 and for generating and transmitting information

related to communication method determination.

[0049]

Accordingly, since it is possible to select the communication mode giving priority to the data quality or to select the communication mode according to the radio wave propagation environment as the communication mode at start of the communication, the data transmission quality can be ensured at start of the communication.

[0050]

A communication method of the present invention is a communication method of transmitting a modulated signal of a plurality of channels from a plurality of antennas to the same frequency band, wherein after a multiplexed signal is separated into a modulated signal of each channel by a pilot symbol used to separate the multiplexed signal and a receiving apparatus, a pilot signal for demodulating the modulated signal of each channel is inserted.

[0051]

A communication method of the present invention is the communication method according to Claim 31, wherein the pilot symbol used to separate the multiplexed signal is transmitted without being multiplexed, and the pilot signal for demodulating the modulated signal of each channel is multiplexed.

[0052]

Accordingly, the multiplexed signal is separated, the modulated signal of each channel can be easily demodulated, and the reception sensitivity is improved.

[0053]

A communication method of the present invention is the

communication method according to Claim 31 or Claim 32, wherein the pilot signal for demodulating the modulated signal of each signal is inserted into only one channel.

[0054]

A communication method of the present invention is a communication method, in a transmitting method of transmitting a modulated signal of a plurality of channels from a plurality of antennas to the same frequency band, wherein deferential encoding is performed between a modulated signal of a first channel and a modulated signal of a second channel.

[0055]

A communication method of the present invention is the communication method according to Claim 34, wherein a modulation mode for the modulated signals of the first channel and the second channel is PSK (Phase Shift Keying) modulation.

[0056]

A communication method of the present invention is a communication method, in a transmitting apparatus of transmitting a modulated signal of a plurality of channels from a plurality of antennas to the same frequency band, wherein with reference to a signal point of the modulated signal of the first channel, a signal point of the modulated signal of the second channel is arranged.

[0057]

A communication method of the present invention is a communication method, in a transmitting apparatus of transmitting a modulated signal of a plurality of channels from a plurality of antennas to the same frequency band, wherein the modulated signal of the first

channel is a pilot signal for the modulated signal of the second channel.

[0058]

A communication method of the present invention is the communication method according to Claim 37, wherein the modulated signal of the first channel is always transmitted.

[0059]

A communication method of the present invention is the communication method according to Claim 37 or Claim 38, wherein control information is transmitted by the modulated signal of the first channel.

[0060]

A communication method of the present invention is the communication method according to anyone of Claims 36 to 39, wherein the modulated signal of the first channel is a PSK modulation mode.

[0061]

A communication method of the present invention is a transmitting apparatus for transmitting the modulated signal of the communication method according to Claim 31 or Claim 32, provided with a pilot symbol signal generation section that separates a multiplexed signal and a signal generation section that generates a modulated signal into which a pilot symbol used to demodulate the modulated signal is inserted.

[0062]

Accordingly, since the number of pilot symbols to be inserted can be reduced, the data transmission speed is improved.

[0063]

A transmitting apparatus of the present invention is a transmitting apparatus for transmitting the modulated signal of the communication method according to Claim 33, provided with a modulated signal generation section that corresponds to each channel: wherein a pilot symbol is inserted into only one modulated signal generation section among a plurality of modulated signal generation sections.

[0064]

Accordingly, the multiplexed signal is separated, the modulated signal of each channel can be easily demodulated, and the reception sensitivity is improved.

[0065]

A transmitting apparatus of the present invention is a transmitting apparatus for transmitting the modulated signal of the communication method according to Claim 34 or Claim 35, provided with a differential encoding section that differentially encodes signals of the first channel and the second channel.

[0066]

A transmitting apparatus of the present invention is a transmitting apparatus for transmitting the modulated signal of the communication method according to Claim 36 provided with an encoding section that arranges a signal point of the demodulated signal of the second channel with reference to the signal point of the modulated signal of the first channel.

[0067]

A transmitting apparatus of the present invention is a transmitting apparatus for transmitting the modulated signal of the communication

method according to Claim 37 provided with a signal generation section that generates a modulated signal of a pilot channel.

[0068]

Accordingly, since the number of pilot symbols can be reduced, the data transmission speed is improved.

[0069]

A receiving apparatus of the present invention is a receiving apparatus for receiving the modulated signal of the communication method according to Claim 31 or Claim 32, provided with a separation section that separates a multiplexed signal by using a pilot symbol used to separate the multiplexed signal and a demodulation section that receives a modulated signal of a separated channel as input, demodulates the modulated signal by the pilot symbol for demodulation, and outputs a received digital signal.

[0070]

Accordingly, the multiplexed signal is separated, the modulated signal of each channel can be easily demodulated, and the reception sensitivity is improved.

[0071]

A receiving apparatus of the present invention is a receiving apparatus for receiving the modulated signal of the communication method according to Claim 33, provided with a first demodulation section that receives a modulated signal of a channel into which a pilot symbol is inserted and a modulated signal of the first channel as input and that demodulates the modulated signal of the first channel by using the pilot symbol inserted into the modulated signal of the channel into which the pilot symbol is inserted.

[0072]

A receiving apparatus of the present invention is a receiving apparatus for receiving the modulated signal of the communication method according to Claim 34 or Claim 35, provided with a differential wave detection section that receives a modulated signal of the first channel and a modulated signal of the second channel as input, performs deferential wave detection, and outputs a received digital signal.

[0073]

A receiving apparatus of the present invention is a receiving apparatus for receiving the modulated signal of the communication method according to Claim 36 or Claim 37, provided with a demodulation section that receives a modulated signal of the first channel and a modulated signal of the second channel as inputs and that demodulates the modulated signal of the second channel based on the modulated signal of the first channel.

[0074]

A receiving apparatus of the present invention is a receiving apparatus for receiving the modulated signal of the communication method according to anyone of Claims 31, 32, 33, and 37, provided with a channel distortion estimation section that estimates a channel distortion by using the pilot symbol.

[0075]

A receiving apparatus of the present invention is a receiving apparatus for receiving the modulated signal of the communication method according to anyone of Claims 31, 32, 33, and 37, that is provided with a frequency offset estimation section that estimates a

frequency offset by using the pilot symbol.

[0076]

Accordingly, since the number of pilot symbols to be inserted can be reduced, the data transmission speed is improved.

[0077]

A transmitting apparatus of the present invention is, in a transmitting method of transmitting a modulated signal of a plurality of channels from a plurality of antennas in the same frequency band, a transmitting apparatus is provided with a frequency source for a transmission base band and a frequency source for a radio section.

[0078]

Accordingly, frequency sources can be reduced in comparison with the case in which frequency sources are each arranged for antennas in the transmitting apparatus.

[0079]

A transmitting apparatus of the present invention is in a transmitting method of transmitting a modulated signal of a plurality of channels from a plurality of antennas in the same frequency band, a transmitting apparatus is provided with a frequency source for a reception base band and a frequency source for a radio section.

[0080]

Accordingly, frequency sources can be reduced in comparison with the case in which frequency sources are each arranged for antennas in the transmitting apparatus. Then, the frequency synchronization and the time synchronization can be easily performed for the channel A signal and the channel B signal.

[0081]

With reference now to the accompanying drawings, embodiments of the present invention will be explained in detail below.

[0082]

(Embodiment 1)

In this embodiment, a description is given of a transmitting apparatus that transmits non-multiplexed and multiplexed carriers in transmit frames in a multicarrier communication system, and a receiving apparatus that can demodulate a modulated signal of either carrier.

[0083]

FIG. 1 is a drawing showing an example of the frame configuration on the frequency-time axes of channel A and channel B according to Embodiment 1 of the present invention. Reference numeral 101 indicates a guard symbol, reference numeral 102 indicates an information symbol, reference numeral 103 indicates an estimation symbol, and reference numeral 104 indicates a control symbol. In FIG. 1, guard symbols 101 are symbols for which there is no modulated signal. Estimation symbols 103 are pilot symbols for estimating, for example, time synchronization, frequency synchronization, and distortion due to the channel fluctuation, or a unique word or preamble, for which a known signal such as a BPSK modulated signal, for example, is suitable. Control symbols 104 are symbols that transmit information used by a terminal for control, and are symbols for transmitting information by means of information symbols 102.

[0084]

In this case, in carrier 1 through carrier 6, only channel A information symbols are transmitted, and in carrier 7 through carrier 12,

channel A information symbols and channel B information symbols are multiplexed and transmitted . Similarly, in carrier 1 through carrier 6, only channel A estimation symbols are transmitted, and in carrier 7 through carrier 12, channel A estimation symbols and channel B estimation symbols are multiplexed and transmitted .

[0085]

FIG. 2 is a block diagram showing one example of the configuration of a transmitting apparatus of this embodiment when the OFDM method is used. A frame configuration signal generation section 221 receives control signal 223 as input, generates frame configuration information based on the control signal, and outputs it as a frame configuration signal 222.

[0086]

Channel A serial/parallel conversion section 202 receives a channel A transmit digital signal 201 and a frame configuration signal 222 as input and outputs a parallel signal 203 in accordance with the frame configuration.

[0087]

Channel A inverse discrete Fourier transform section 204 receives a channel A parallel signal 203 as input and outputs a channel A post-inverse-discrete-Fourier-transform signal 205.

[0088]

Channel A radio section 206 receives post-inverse-discrete-Fourier-transform signal 205 as input and outputs channel A transmit signal 207.

[0089]

Channel A power amplification section 208 receives as input and

amplifies channel A transmit signal 207 and outputs amplified channel A transmit signal 209 from channel A antenna 210 as a radio wave.

[0090]

Channel B serial/parallel conversion section 212 receives a channel B transmit digital signal 211 and frame configuration signal 222 as input and outputs a channel B parallel signal 213 in accordance with the frame configuration.

[0091]

Channel B inverse discrete Fourier transform section 214 receives channel B parallel signal 213 as input and outputs a channel B post-inverse-discrete-Fourier-transform signal 215.

[0092]

Channel B radio section 216 receives a channel B post-inverse-discrete-Fourier-transform signal 215 as input and outputs channel B transmit signal 217.

[0093]

Channel B power amplification section 218 receives as input and amplifies channel B transmit signal 217 and outputs a channel B amplified transmit signal 219 from channel B antenna 220 as a radio wave.

[0094]

FIG. 3 shows one example of a configuration of a receiving apparatus according to this embodiment, and a radio section 303 receives a received signal 302 received by an antenna 301 as input and outputs received quadrature baseband signal 304.

[0095]

Fourier transform section 305 receives received quadrature

baseband signal 304 as input and outputs parallel signal 306.

[0096]

Channel A transmission path distortion estimation section 307 receives parallel signal as input 306 and outputs a channel A transmission path distortion parallel signal 308.

[0097]

Channel B transmission path distortion estimation section 309 receives parallel signal 306 as input and outputs a channel B transmission path distortion parallel signal 310.

[0098]

A radio section 313 receives a received signal 312 received by an antenna 311 as input and outputs received quadrature baseband signal 314.

[0099]

Fourier transform section 315 receives received quadrature baseband signal 314 as input and outputs parallel signal 316.

[0100]

Channel A transmission path distortion estimation section 317 receives parallel signal as input 316 and outputs a channel A transmission path distortion parallel signal 318.

[0101]

Channel B transmission path distortion estimation section 319 receives parallel signal 316 as input and outputs a channel B transmission path channel distortion parallel signal 320.

[0102]

Signal processing section 321 receives parallel signals 306 and 316, channel A transmission path distortion parallel signals 308 and

318, and channel B transmission path distortion parallel signals 310 and 320, as input, separates channel A and channel B signals of carrier 7 through carrier 12 in which channel A and channel B are multiplexed in FIG. 1, and outputs carrier 7 through carrier 12 channel A parallel signal 322 and carrier 7 through carrier 12 channel B parallel signal 323.

[0103]

Carrier 7 through carrier 12 channel A demodulation section 324 receives carrier 7 through carrier 12 channel A parallel signal 322 as input and outputs a carrier 7 through carrier 12 channel A received digital signal 325.

[0104]

Carrier 7 through carrier 12 channel B demodulation section 326 receives carrier 7 through carrier 12 channel B parallel signal 323 as input and outputs a carrier 7 through carrier 12 channel B received digital signal 327.

[0105]

Selection section 328 receives parallel signals 306 and 316 as input, selects the parallel signal with the greater field strength, for example, and outputs the selected parallel signal as parallel signal 329.

[0106]

Carrier 1 through carrier 6 channel A demodulation section 330 receives selected parallel signal 329 as input, estimates the channel distortion from non-multiplexed carrier 1 through carrier 6 estimation symbols 103 in FIG. 1, demodulates the carrier 1 through carrier 6 parallel signal from the estimated channel distortion, and outputs a carrier 1 through carrier 6 received digital signal 331.

[0107]

Frequency offset estimation section 332 receives parallel signal 306 and 316 as input, estimates the frequency offset amount from estimation symbols 103 in FIG. 1, and outputs a frequency offset estimation signal 333. For example, a frequency offset estimation signal is input to radio sections 303 and 313, and the received signal frequency offset is eliminated.

[0108]

Synchronization section 334 receives quadrature baseband signals 304 and 314 as input, establishes time synchronization by, for example, the estimation symbol 103 in FIG. 1, and outputs a timing signal 335.

[0109]

Using FIG. 1, FIG. 2, and FIG. 3, detailed explanations are given of the operation of a transmitting apparatus and a receiving apparatus of this embodiment.

[0110]

The operations of the transmitting apparatus will be described.

[0111]

Channel A serial/parallel conversion section 202 receives channel A transmit digital signal 201 and frame configuration signal 222 as input, and outputs channel A parallel signal 203 so as to place symbols in accordance with the channel A frame configuration in FIG. 1 - that is to say, so as to place information symbols, control symbols, and estimation symbols in carrier 1 through carrier 12.

[0112]

Channel B serial/parallel conversion section 212 receives channel B transmit digital signal 211 and frame configuration signal 222 as

input, and outputs channel B parallel signal 213 so as to place symbols in accordance with the channel B frame configuration in FIG. 1 - that is to say, so as to place information symbols, control symbols, and estimation symbols in carrier 7 through carrier 12.

[0113]

Estimation symbols 103 are inserted for time synchronization and frequency offset estimation. Also, channel A carrier 1 through carrier 6 estimation symbols are used by a receiving apparatus to estimate transmission path distortion and demodulate channel A carrier 1 through carrier 6 information symbols. At this time, estimation symbols are not inserted in carrier 1 through carrier 6 in channel B. Estimation symbols of channel A and channel B carrier 7 through carrier 12 are symbols for separating information symbols of channel A and channel B carrier 7 through carrier 12. For example, by using mutually orthogonal symbols for estimation symbols comprising channel A carrier 7 through carrier 12 and estimation symbols comprising channel B carrier 7 through carrier 12, it is easy to separate information symbols of channel A and channel B carrier 7 through carrier 12.

[0114]

When channel A carrier 1 through carrier 6 information symbols and channel A and channel B carrier 7 through carrier 12 information symbols are compared, in the receiving apparatus channel A carrier 1 through carrier 6 information symbols are of better quality than channel A and channel B carrier 7 through carrier 12 information symbols. Considering this fact, it is appropriate for information of high importance to be transmitted in channel A carrier 1 through carrier

6 information symbols.

[0115]

It is also possible to transmit one kind of information medium in channel A in carrier 1 through carrier 6, and transmit one kind of information medium in channel A and channel B in carrier 7 through carrier 12, such as transmitting video information, for example, using carrier 1 through carrier 6 channel A information symbols, and transmitting Hi-Vision video using carrier 7 through carrier 12 channel A and channel B information symbols. Also, the same kind of information medium may be transmitted in carrier 1 through carrier 6 channel A transmission and carrier 7 through carrier 12 channel A and channel B transmission. At this time, the compression ratio when coding, for example, will be different for the same kind of information.

[0116]

It is also possible to transmit information in a hierarchical fashion, with a certain kind of information transmitted by means of carrier 1 through carrier 6 channel A information symbols, and difference information transmitted using carrier 7 through carrier 12 channel A and channel B information symbols.

[0117]

The operation of a receiving apparatus is explained.

[0118]

Synchronization section 334 is able to establish time synchronization with the transmitting apparatus and the receiving apparatus by detecting estimation symbols 103 in FIG. 1 in received quadrature baseband signal 304 and received quadrature baseband signal 314.

[0119]

Frequency offset estimation section 332 estimates the frequency offset from estimation symbols 103 in parallel signal 306 and 316 in FIG. 1.

[0120]

Signal processing section 321 separates channel A and channel B carrier 7 through carrier 12 multiplexed signals in FIG. 1 into carrier 7 through carrier 12 channel A signal and carrier 7 through carrier 12 channel B signal, and outputs them as carrier 7 through carrier 12 channel A parallel signal 322 and carrier 7 through carrier 12 channel B parallel signal 323 respectively.

[0121]

Carrier 7 through carrier 12 channel A demodulation section 324 receives carrier 7 through carrier 12 channel A parallel signal 322 as input, and outputs a carrier 7 through carrier 12 channel A received digital signal 325. Also, carrier 7 through carrier 12 channel B demodulation section 326 receives carrier 7 through carrier 12 channel B parallel signal 323 as input, and outputs a carrier 7 through carrier 12 channel B received digital signal 327. Carrier 1 through carrier 6 demodulation section 330 receives selected parallel signal 329 as input, estimates channel distortion from non-multiplexed carrier 1 through carrier 6 estimation symbols 103 in FIG. 1, demodulates the carrier 1 through carrier 6 parallel signal from the estimated channel distortion, and outputs carrier 1 through carrier 6 received digital signal 331. At this time, received digital signals 325 and 327 obtained from carrier 7 through carrier 12 channel A and channel B are of poor quality in comparison with carrier 1 through carrier 6 channel

A received digital signal 331, but can be transmitted at high speed. Therefore, carrier 1 through carrier 6 channel A received digital signal 331 is suitable for transmission of important information and transmission of control information. Received digital signals 325 and 327 obtained from carrier 7 through carrier 12 channel A and channel B are input to a decoder X, and decoded. Then carrier 1 through carrier 6 channel A received digital signal 331 is input to a decoder Y, and decoded. By this means, different information X and Y can be obtained from different decoders X and Y, and although the information is the same in decoders X and Y, it is possible to transmit information with different compression ratios.

[0122]

It is possible to perform hierarchical transmission in which video is transmitted by means of carrier 1 through carrier 6 channel A received digital signal 331 and difference information for Hi-Vision video is transmitted by received digital signals 325 and 327 obtained from carrier 7 through carrier 12 channel A and channel B.

[0123]

In FIG. 1, FIG. 2, and FIG. 3, the use of multiplex frames and non-multiplexed frames with two channels and two antennas has been illustrated as an example, but the present invention is not limited to this. For example, it is possible to implement the present invention similarly with multiplex frames using three channels and three antennas, multiplex frames using two channels and two of three antennas, and frames that cause the existence of non-multiplexed frames. Also, the frame configurations are not limited to those in FIG. 1. Furthermore, an example has been described in which OFDM is used as the

communication method, but it is possible to implement the present invention similarly as long as a multicarrier method is used. Moreover, a spread spectrum communication method may be used as the method for each carrier in a multicarrier system. Thus, it is possible to implement the present invention similarly with OFDM-CDM (Orthogonal Frequency Division Multiplex - Code Division Multiplex).

[0124]

Furthermore, there are also cases where one antenna is composed of a plurality of antennas.

[0125]

Thus, by creating frames whereby a plurality of modulated signals are transmitted from a plurality of antennas and frames whereby a modulated signal is transmitted from one antenna and by transmitting important information in a modulated signal transmitted from one antenna, it is possible to secure data quality in a receiving apparatus. Also, by transmitting different information in frames whereby a plurality of modulated signals are transmitted from a plurality of antennas and frames whereby a modulated signal is transmitted from one antenna, it is possible to transmit information of different quality and transmission speed.

[0126]

(Embodiment 2)

In Embodiment 2, a description is given of a communication method, transmitting apparatus, and receiving apparatus whereby, when a multicarrier communication system is used in which a base station performs communication with a plurality of terminals, non-multiplexed carriers and multiplexed carriers are provided in base station transmit

frames, and a modulated signal is transmitted to a terminal using one or other of these types of carrier.

[0127]

FIG. 1 shows one example of the frame configuration of the base station transmit signal in this embodiment, FIG. 2 shows one example of the configuration of the transmitting apparatus in the base station, and the operation is described above.

[0128]

FIG. 4 shows an example of the arrangement of a base station and terminals according to Embodiment 2 of the present invention. In FIG. 4, reference numeral 401 indicates a base station, reference numeral 402 indicates terminal A, reference numeral 403 indicates terminal B, reference numeral 404 indicates terminal C, reference numeral 405 indicates terminal D, and reference numeral 406 indicates the communication limit of base station 401 transmit signals.

[0129]

FIG. 5 shows an example of the configuration of a receiving apparatus of this embodiment. Parts in FIG. 5 identical to those in FIG. 3 are assigned the same reference numerals as in FIG. 3.

[0130]

A radio wave propagation environment estimation section 501 receives parallel signals 306 and 316 as input, estimates the field strength, multipath environment, Doppler frequency, direction of arrival, channel fluctuation, interference intensity, polarized wave state, and delay profile of received signals received by antenna 301 and the field strength, multipath environment, Doppler frequency, direction of arrival, channel fluctuation, interference intensity, polarized wave state,

and delay profile of received signals received by antenna 311, and outputs this information as radio wave propagation environment information to 502.

[0131]

FIG. 6 shows an example of the configuration of a transmitting apparatus of this embodiment. An information generation section 604 receives data 601, radio wave propagation environment information 602, and request information 603 that a user or communication terminal considers necessary, such as transmission speed, modulation method, and received data quality, for example, as input, and generates and outputs a transmit digital signal 605.

[0132]

Modulated signal generation section 606 receives transmit digital signal 605 as input and outputs a transmit quadrature baseband signal 607.

[0133]

Radio section 608 receives transmit quadrature baseband signal 607 as input and outputs a modulated signal 609, which is output as a radio wave from an antenna 610.

[0134]

FIG. 7 shows an example of the configuration of a receiving apparatus that receives the signal transmitted from one terminal of the base station. In FIG. 7, a radio section 703 receives a received signal 702 received by an antenna 701 as input and outputs a received quadrature baseband signal 704.

[0135]

Demodulation section 705 receives received quadrature baseband

signal 704 as input and outputs a received digital signal 706.

[0136]

Method determination section 708 extracts radio wave propagation environment information and request information contained in received digital signal 706, selects the method whereby the base station transmits to a terminal - that is, either a method whereby signals of a plurality of channels are transmitted from a plurality of antennas, or a method whereby signals of a plurality of channels are not multiplexed and a signal of one channel is transmitted - and outputs this as a control signal 708.

[0137]

Using FIG. 1, FIG. 2, FIG. 4, FIG. 5, FIG. 6, and FIG. 7, detailed explanations are given of the communication method among the base station and the terminals.

[0138]

When the locations of the base station and terminals are as shown in FIG. 4, the reception status of terminal A 402 and terminal B 403 located far from base station 401 is poor, while the reception status of terminal C 404 and terminal D 405 is good as they are near base station 401. Considering this, it is assumed that assignment is performed to communication terminals in 3-carrier units as shown in FIG. 1, for example. In this case, in FIG. 1, carrier 7 through carrier 9 are assigned for communication with terminal C 404 and carrier 10 through carrier 12 are assigned for communication with terminal C 405, for both of which terminals the reception status is good, and communication is performed on channel A and channel B, so that the transmission speed is high. Also, carrier 1 through carrier 3 are

assigned for communication with terminal A 402 and carrier 4 through carrier 6 in FIG. 2 are assigned for communication with terminal B 403, for both of which terminals the reception status is poor, and communication is performed on channel A, so that the transmission speed is low but received data quality is good.

[0139]

At this time, by transmitting information concerning channel assignment by means of control symbols 103 in FIG. 1, and having a terminal demodulate control symbols 103, it is possible to ascertain where in a frame information for that terminal is assigned.

[0140]

Next, the receiving apparatus and the transmitting apparatus in the terminal will be described in detail.

[0141]

FIG. 5 shows an example of the configuration of a receiving apparatus of the terminal. A radio wave propagation environment estimation section 501 receives parallel signals 306, 316 as input, estimates the field strength, multipath environment, Doppler frequency, direction of arrival, channel fluctuation, interference intensity, polarized wave state, and delay profile of received signals received by antenna 301 and antenna 311 from estimation symbols 103 in FIG. 1, and outputs this information as radio wave propagation environment information 502.

[0142]

FIG. 6 shows an example of the configuration of the transmitting apparatus of the terminal. Radio wave propagation environment information 502 estimated by radio wave propagation environment

estimation section 501 of the receiving apparatus in FIG. 5 corresponds to radio wave propagation environment information 602, and is input to information generation section 604.

[0143]

Information generation section 604 receives data 601, radio wave propagation environment information 602, and request information 603 that a user or communication terminal considers necessary, such as transmission speed, modulation method, and received data quality, for example, as input and generates and outputs transmit digital signal 605. By this means, a terminal transmits a signal containing the radio wave propagation environment when the terminal receives a modulated signal transmitted from the base station, and request information requested by the user or terminal.

[0144]

Also, as a separated operation from this, information generation section 604 has radio wave propagation environment 602 and request information 603 comprising information that the user or terminal considers necessary, such as transmission speed, modulation method, and received data quality, for example, as input, determines and requests a communication method from radio wave propagation environment 602 and request information 603, and outputs transmit digital signal 605. At this time, information on the requested communication method is included in transmit digital signal 605. Here, "communication method" is information as to whether communication is performed by means of a multiplex signal or whether communication is performed by means of a non-multiplexed signal.

[0145]

Next, detailed explanations are given of the transmitting apparatus and the receiving apparatus in the base station.

[0146]

FIG. 7 shows an example of the configuration of a receiving apparatus that receives the signal transmitted from terminal A, for example. Method determination section 707 extracts radio wave propagation environment information and request information contained in signal from transmitted from the transmitting apparatus in FIG. 6 of the terminal A or the requested communication method information, selects either a method whereby signals of a plurality of channels are transmitted from a plurality of antennas, or a method whereby signals of a plurality of channels are not multiplexed and a signal of one channel is transmitted, and outputs this as a control signal 708.

[0147]

Frame configuration signal generation section 221 in the base station transmitting apparatus in FIG. 2 receives control signal 708 from a terminal A, terminal B, terminal C, or terminal D receiving apparatus as input control signal 223, and outputs frame configuration signal 222. By this means, modulated signals conforming to the frame configurations in FIG. 1 can be transmitted by the base station transmitting apparatus.

A description will now be given of the means of setting the communication method at the start of communication.

[0148]

Considering reception quality with respect to the radio wave propagation environment, the quality of carrier 1 through carrier 6

channel A information symbols is good in comparison with carrier 7 through carrier 12 channel A information symbols and channel B information symbols.

[0149]

Therefore, when a terminal and base station start communicating, the base station maintains data quality by transmitting information to the terminal in carrier 1 through carrier 6 channel A information symbols, thereby providing system stability.

[0150]

Alternatively, when a terminal and base station start communicating, the base station first transmits estimation symbols 103 as shown in FIG. 1 to the terminal, the terminal receives the initially transmitted estimation symbols 103, estimates the radio wave propagation environment, and transmits radio wave propagation environment estimation information and request information. Then, based on the radio wave propagation environment information and request information from the terminal, the base station selects either transmission of information by means of carrier 1 through carrier 6 channel A information symbols or transmission of information by means of carrier 7 through carrier 12 channel A information symbols and channel B information symbols, and starts communication. By this means, data quality can be maintained and therefore system stability is achieved.

[0151]

Alternatively, when a terminal and base station start communicating, the base station first transmits estimation symbols 103 as shown in FIG. 1 to the terminal, the terminal receives the initially

transmitted estimation symbols 103, estimates the radio wave propagation environment, takes radio wave propagation environment estimation information and request information into consideration, selects either transmission of information by means of carrier 1 through carrier 6 channel A information symbols or transmission of information by means of carrier 7 through carrier 12 channel A information symbols and channel B information symbols, and makes a request to the base station. Based on the request from the terminal, the base station selects either transmission of information by means of carrier 1 through carrier 6 channel A information symbols or transmission of information by means of carrier 7 through carrier 12 channel A information symbols and channel B information symbols, and starts communication. By this means, data quality can be maintained and therefore system stability is achieved.

[0152]

In the above description, the use of multiplex frames and non-multiplexed frames with two channels and two antennas has been illustrated in FIG. 1, FIG. 2, and FIG. 3 as an example, but the present invention is not limited to this. For example, it is possible to implement the present invention similarly with multiplex frames using three channels and three antennas, multiplex frames using two channels and two of three antennas, and frames that cause the existence of non-multiplexed frames. Also, the frame configurations are not limited to those in FIG. 1. Furthermore, an example has been described in which OFDM is used as the communication method, but it is possible to implement the present invention similarly as long as a multicarrier method is used. Moreover, a spread spectrum

communication method may be used as the method for each carrier in a multicarrier system. Thus, it is possible to implement the present invention similarly with OFDM-CDM.

[0153]

Furthermore, there are also cases where one antenna is composed of a plurality of antennas.

[0154]

Thus, when a base station performs communication with a plurality of terminals, by assigning non-multiplexed carriers in base station transmit frames in communication with a terminal whose reception status is poor, and assigning multiplexed carriers in communication with a terminal whose reception quality is good, it is possible for a terminal to achieve compatibility between data transmission speed and received data quality.

[0155]

(Embodiment 3)

In Embodiment 3, a description is given of a transmitting apparatus that transmits a frequency of a multiplexed modulated signal and a frequency of a non-multiplexed modulated signal in a transmitting apparatus transmit frame, and a receiving apparatus that can demodulate a modulated signal of either frequency.

[0156]

FIG. 8 shows an example of frame configurations on the frequency-time axes of base station transmit signal channel A and channel B in frequency band f1 according to this embodiment. Reference numeral 102 indicates an information symbol, reference numeral 103 indicates an estimation symbol, and reference numeral 104

indicates a control symbol. Estimation symbols 103 are pilot symbols for estimating time synchronization, frequency synchronization, and distortion due to the channel fluctuation, and control symbols 104 are symbols that transmit information used by a terminal for control, and are symbols for transmitting information by means of information symbols 102.

[0157]

At this time, channel A and channel B signals are transmitted from two antennas respectively.

[0158]

FIG. 9 shows an example of a frame configuration on the frequency-time axes of base station transmit signal channel C in frequency band f2 according to this embodiment. Reference numeral 102 indicates an information symbol, reference numeral 103 indicates an estimation symbol, and reference numeral 104 indicates a control symbol. Estimation symbols 103 are pilot symbols for estimating time synchronization, frequency synchronization, and distortion due to the channel fluctuation, and control symbols 104 are symbols that transmit information used by a terminal for control, and are symbols for transmitting information by means of information symbols 102.

[0159]

A channel C signal is transmitted from one antenna.

[0160]

FIG. 10 shows the base station transmit signal frequency arrangement according to this embodiment. Reference numeral 1001 indicates a channel A and channel B multiplex transmit signal, with the frequency band designated f1. Reference numeral 1002 indicates a

channel C multiplex transmit signal, with the frequency band designated f2.

[0161]

FIG. 11 shows an example of the configuration of a transmitting apparatus of a base station according to this embodiment. Parts in FIG. 11 identical to those in FIG. 2 are assigned the same reference numerals as in FIG. 2.

[0162]

Channel C serial/parallel conversion section 1102 receives a channel C transmit digital signal 1101 and channel C frame configuration signal 222 as input and outputs parallel signal 1103 in accordance with the frame configuration.

[0163]

Channel C inverse discrete Fourier transform section 1104 receives channel C parallel signal 1103 as input and outputs a channel C post-inverse-Fourier-transform signal 1105.

[0164]

Channel C radio section 1106 receives channel C post-inverse-Fourier-transform signal 1105 as input and outputs a channel C transmit signal 1107.

[0165]

Channel C power amplification section 1108 receives as input and amplifies channel C transmit signal 1107, and outputs an amplified C transmit signal 1109 as a radio wave from a channel C antenna 1110.

[0166]

FIG. 12 shows the configuration of a receiving apparatus of a terminal according to this embodiment. Radio section 1203 receives

a frequency band f1 received signal 1202 received by an antenna 1201 as input, and outputs a received quadrature baseband signal 1204.

[0167]

Fourier transform section 1205 receives received quadrature baseband signal 1204 as input, and outputs parallel signal 1206.

[0168]

Channel A channel distortion estimation section 1207 receives parallel signal 1206 as input and outputs a channel A channel distortion parallel signal 1208.

[0169]

Channel B Channel distortion estimation section 1209 receives parallel signal 1206 as input and outputs a channel B channel distortion parallel signal 1210.

[0170]

A radio section 1213 receives a received signal 1212 received by an antenna 1211 on frequency band f1 as input, and outputs a received quadrature baseband signal 1214.

[0171]

Fourier transform section 1215 receives received quadrature baseband signal 1214 as input, and outputs parallel signal 1216.

[0172]

Channel A channel distortion estimation section 1217 receives parallel signal 1216 as input and outputs a channel A channel distortion parallel signal 1218.

[0173]

Channel B channel distortion estimation section 1219 receives parallel signal 1216 as input, and outputs a channel B channel

distortion parallel signal 1220.

[0174]

Signal processing section 1221 receives parallel signals 1206 and 1216, channel A channel distortion parallel signals 1208 and 1218, and channel B channel distortion parallel signals 1210 and 122 as input, and outputs channel A parallel signal 1222 and outputs channel B parallel signal 1223.

[0175]

Channel A demodulation section 1224 receives channel A parallel signal 1222 as input, and outputs a channel A received digital signal 1225.

[0176]

Channel B demodulation section 1226 receives channel B parallel signal 1223 as input, and outputs a channel B received digital signal 1227.

[0177]

Frequency offset estimation section 1228 receives parallel signal 1206 and 1216 as input, estimates the frequency offset amount from estimation symbols 103 in FIG. 8, and outputs a frequency offset estimation signal 1229. Then, the frequency offset estimation signal is input to radio sections 1203 and 1213, for example, to eliminate the received signal frequency offset.

[0178]

Synchronization section 1230 receives received quadrature baseband signals 1204 and 1214 as input, acquires time synchronization, and outputs a timing signal 1231.

[0179]

A radio section 1234 receives a frequency band f2 received signal 1233 received by an antenna 1232 as input, and outputs a received quadrature baseband signal 1235.

[0180]

Fourier transform section 1236 receives received quadrature baseband signal 1235 as input, and outputs parallel signal 1237.

[0181]

Channel distortion estimation section 1238 receives parallel signal 1237 as input, and outputs a channel distortion parallel signal 1239.

[0182]

Demodulation section 1240 channel receives parallel signal 1237 and distortion parallel signal 1239 as input, eliminates channel distortion from parallel signal 1237, demodulates the signal, and outputs a channel C received digital signal 1241.

[0183]

Using FIG. 8, FIG. 9, FIG. 10, FIG. 11, and FIG. 12, the operation of the transmitting apparatus and the receiving apparatus will be described in detail.

[0184]

FIG. 10 shows one example of the base station transmit signal frequency arrangement according to this embodiment. In FIG. 10, carriers are arranged in frequency f1 and frequency f2, and frequency f1 is assigned for base station transmission, the frame configurations at this time being as shown in FIG. 8. Frequency f2 is assigned for base station transmission, the frame configuration at this time being as shown in FIG. 9. At frequency f1, for example, channel A and channel

B are transmitted and are multiplexed, and the transmission speed is high but received data quality is poor. At frequency f2, on the other hand, channel C is transmitted, and as there is no multiplexing, the transmission speed is low but received data quality is good.

[0185]

FIG. 11 shows an example of the configuration of a transmitting apparatus according to this embodiment.

[0186]

Channel A serial/parallel conversion section 202 receives channel A transmit digital signal 201 and frame configuration signal 222 as input and outputs channel A parallel signal 203 in which information symbols, control symbols, and estimation symbols are present, in accordance with the channel A frame configuration in FIG. 8.

[0187]

Channel B serial/parallel conversion section 212 receives channel B transmit digital signal 211 and frame configuration signal 222 as input and outputs channel B parallel signal 213 in which information symbols, control symbols, and estimation symbols are present, in accordance with the channel B frame configuration in FIG. 8.

[0188]

Channel A and channel B signals are then transmitted at frequency f1.

[0189]

Estimation symbols 103 in FIG. 8 are inserted for time synchronization and frequency offset estimation. They are also signals for performing channel estimation for separating channel A and channel B signals.

[0190]

Channel C serial/parallel conversion section 1102 receives channel B transmit digital signal 1101 and frame configuration signal 222 as input and outputs channel C parallel signal 1103 in which information symbols, control symbols, and estimation symbols are present, in accordance with the channel C frame configuration in FIG. 9.

[0191]

A channel C signal is then transmitted at frequency f2.

[0192]

Estimation symbols 103 in FIG. 9 are inserted for time synchronization and frequency offset estimation.

[0193]

When channel A information symbols and channel A and channel B information symbols are compared with channel C information symbols, in the receiving apparatus they are of better quality than channel C information symbols. Considering this fact, it is appropriate for information of high importance to be transmitted in channel C information symbols.

[0194]

It is possible to transmit one kind of information medium in channel C, and transmit one kind of information medium in channel A and channel B, such as transmitting video information, for example, using channel C information symbols, and transmitting Hi-Vision video using channel A and channel B information symbols. Also, the same kind of information medium may be transmitted in channel C transmission and channel A and channel B transmission. At this time,

the compression ratio when coding, for example, will be different for the same kind of information.

[0195]

It is also possible to transmit information in a hierarchical fashion, with a certain kind of information transmitted by means of channel C information symbols, and difference information transmitted using channel A and channel B information symbols.

[0196]

Next, the operation of the receiving apparatus will be described.

[0197]

Synchronization section 1230 acquires time synchronization between the receiving apparatus and the transmitting apparatus by detecting estimation symbols 103 in FIG. 8 in a received quadrature baseband signal 1204 and a received signal 1214.

[0198]

Frequency offset estimation section 1228 estimates the frequency offset amount from estimation symbols 103 in FIG. 8in parallel signal 1206 and 1216.

[0199]

Signal processing section 1221 separates channel A and channel B multiplexed signals 1206 and 1216 in FIG. 8 into channel A and channel B signals and outputs channel A parallel signal 1222 and channel B parallel signal 1223.

[0200]

Synchronization section 1244 acquires time synchronization from estimation symbols in FIG. 9 in received quadrature baseband signal 1235.

[0201]

Frequency offset estimation section 1242 estimates the frequency offset from estimation symbols 103 in FIG. 9 in parallel signal 1237.

[0202]

Channel distortion estimation section 1238 receives parallel signal 1237 as input, estimates channel distortion from estimation symbols in FIG. 9, and outputs a channel distortion parallel signal 1239.

[0203]

Channel C demodulation section 1240 receives parallel signal 1237 and channel distortion parallel signal 1239 as input, demodulates information symbols 102 in FIG. 9, and outputs a channel C received digital signal 1241.

[0204]

At this time, received digital signals 1225 and 1227 obtained from channel A and channel B are of poor quality in comparison with channel C received digital signal 1241, but can be transmitted at high speed. Considering this fact, channel C received digital signal 1241 is suitable for transmission of important information and transmission of control information. Received digital signals 1225 and 1227 obtained from channel A and channel B are input to a decoder X, and decoded. Then channel C received digital signal 1241 is input to a decoder Y, and decoded. By this means, different information X and Y can be obtained from different decoders X and Y, and although the information is the same in decoders X and Y, it is possible to transmit information with different compression ratios.

[0205]

It is possible to perform hierarchical transmission in which video is transmitted by means of channel C received digital signal 1241 and difference information for Hi-Vision video is transmitted by received digital signals 1225 and 1227 obtained from channel A and channel B.

[0206]

In FIG. 8, the use of multiplex frames on two channels is illustrated, but the present invention is not limited to this. Also, in FIG. 10, an example with two frequency bands is illustrated, but the present invention is not limited to this. For example, it is possible for there to be three frequency bands, and for frequencies to be assigned for 3-channel multiplex transmission, 2-channel multiplex transmission, and single-channel transmission. A description has been given above that refers to a configuration with two antennas transmitting two channels and one antenna transmitting one channel in the transmitting apparatus in FIG. 11, but the present invention is not limited to this. For example, the transmitting apparatus may be equipped with two or more antennas for transmitting two channels. Also, in the case where there are three frequency bands, and frequencies are assigned for 3-channel multiplex transmission, 2-channel multiplex transmission, and single-channel transmission, the transmitting apparatus may be equipped with a plurality of antennas for 3-channel multiplex transmission, or may be equipped with a plurality of antennas for 2-channel multiplex transmission, or may be equipped with a plurality of antennas for single-channel transmission. The same applies to the receiving apparatus in FIG. 12. Furthermore, an example has been described in which OFDM is used as the communication method, but it is possible to implement the present invention similarly as long as a

multicarrier method is used. Moreover, a spread spectrum communication method may be used as the method for each carrier in a multicarrier system. Thus, it is possible to implement the present invention similarly with OFDM-CDM (Orthogonal Frequency Division Multiplex - Code Division Multiplex).

[0207]

Furthermore, there are also cases where one antenna is composed of a plurality of antennas.

[0208]

Thus, there is a frequency for transmitting a plurality of modulated signals from a plurality of antennas and a frequency for transmitting a modulated signal from one antenna, and by transmitting important information in a modulated signal transmitted from one antenna, it is possible to secure data quality in a receiving apparatus. Also, by transmitting different information at a frequency for transmitting a plurality of modulated signals from a plurality of antennas and a frequency for transmitting a modulated signal from one antenna, it is possible to transmit information of different quality and transmission speed.

[0209]

(Embodiment 4)

In Embodiment 4, a description is given of a communication method, transmitting apparatus, and receiving apparatus whereby, when a base station performs communication with a plurality of terminals, a frequency of a multiplexed modulated signal and a frequency of a non-multiplexed modulated signal are provided in transmit frames, and a modulated signal is transmitted to a terminal using one or other of

these frequencies.

[0210]

FIG. 4 shows an example of the arrangement of the base station and the terminals according to Embodiment 4. FIG. 7 shows one example of the configuration of the receiving apparatus of the base station according to this embodiment. FIG. 8 shows one example of the frame configuration of the base station transmit signal according to this embodiment. FIG. 9 shows one example of the frame configuration of the base station transmit signal according to this embodiment. FIG. 10 shows one arrangement of the base station transmit signal. FIG. 11 shows one example of the configuration of the transmitting apparatus of the base station according to this embodiment. Details are described above.

[0211]

FIG. 13 shows one example of the configuration of the receiving apparatus of the terminal according to this embodiment, and parts identical to those in FIG. 12 are assigned the same reference numerals as in FIG. 12.

[0212]

Radio wave propagation environment estimation section 1301 receives parallel signals 1206 and 1216 as input, estimates the radio wave propagation environments of received signals received by antenna 1201 and antenna 1211, respectively, and outputs radio wave propagation environment estimation information 1302.

[0213]

Radio wave propagation environment estimation section 1303 receives parallel signal 1237 as input, estimates the radio wave

propagation environment of a received signals received by antenna 1232, and outputs radio wave propagation environment estimation information 1304.

[0214]

FIG. 14 shows an example of the configuration of a transmitting apparatus of a base station according to this embodiment. Parts in FIG. 14 identical to those in FIG. 6 are assigned the same reference numerals as in FIG. 6.

[0215]

Information generation section 604 has transmit digital signal 601, radio wave propagation environment information 1401 and 1402, and request information 603 as input and outputs and generates transmit digital signal 605.

[0216]

Using FIG. 4, FIG. 7, FIG. 8, FIG. 9, FIG. 10, FIG. 11, FIG. 13, and FIG. 14, the communication method among the base station and the terminals according to this embodiment is explained in detail.

[0217]

It is assumed that the locations of the base station and terminals are as shown in FIG. 4. At this time, the reception status of terminal A 402 and terminal B 403 located far from base station 401 is poor, while the reception status of terminal C 404 and terminal D 405 is good as they are near base station 401. Considering this, for example, as shown in FIG. 8, assignment is performed for communication terminals with regard to time-unit or frequency-unit. For example, time 3 through time 6 are assigned for communication with terminal C and time 7 through time 10 are assigned for communication with terminal D.

Alternatively, carrier 1 through carrier 3 are assigned for communication with terminal C and carrier 4 through carrier 6 are assigned for communication with terminal D. At this time, communication is performed on channel A and channel B, so that the transmission speed is high.

[0218]

Then, assignment is performed for terminal A 402 and terminal B 403 for both of which the reception status is poor, with regard to time-unit or frequency-unit, as shown in FIG. 9. For example, time 3 through time 6 are assigned for communication with terminal A, and time 7 through time 10 are assigned for communication with terminal B. Alternatively, carrier 1 through carrier 3 are assigned for communication with terminal A and carrier 4 through carrier 6 are assigned for communication with terminal B. At this time, communication is performed on channel C, so that the transmission speed is low but received data quality is good.

[0219]

Also, as shown in FIG. 10, the multiplexed signal of channel A and channel B in FIG. 8 is transmitted at frequency f1, and the multiplexed signal of channel C in FIG. 9 is transmitted at frequency f2.

[0220]

At this time, information concerning channel assignment is transmitted by control symbols 103 in FIG. 8 or FIG. 9, a terminal demodulates control symbols 103, whereby it is possible to ascertain where a frame information for that terminal is assigned.

[0221]

The operation of the receiving apparatus and transmitting apparatus

of a terminal will now be described in detail.

[0222]

FIG. 13 shows one example of the receiving apparatus of the terminal. In FIG. 13, radio wave propagation environment estimation section 1301 receives parallel signals 1206 and 1216 as input, estimates the field strength, multipath environment, Doppler frequency, direction of arrival, channel fluctuation, interference intensity, polarized wave state, and delay profile of a signal received by antenna 1201 and a signal received by antenna 1211 from estimation symbols 103 in FIG. 8, for example, and outputs them as radio wave propagation environment information 1302.

[0223]

Radio wave propagation environment estimation section 1303 receives parallel signal 1237 as input, estimates the field strength, multipath environment, Doppler frequency, direction of arrival, channel fluctuation, interference intensity, polarized wave state, and delay profile of a signal received by antenna 1232 from estimation symbols 103 in FIG. 9, and outputs them as radio wave propagation environment information 1304.

[0224]

FIG. 14 shows one example of the configuration of the transmitting apparatus of the terminal. Radio wave propagation environment estimation information 1302 estimated by radio wave propagation environment estimation section 1301 of the receiving apparatus in FIG. 13 corresponds to radio wave propagation environment information 1401, and radio wave propagation environment estimation information 1304 estimated by radio wave propagation environment estimation

section 1303 corresponds to radio wave propagation environment information 1402, and radio wave propagation environment information 1401 and radio wave propagation environment information 1402 are input to information generation section 604.

[0225]

Information generation section 604 receives data 601, radio wave propagation environment information 1401 and 1402, and request information 603 that a user or communication terminal considers necessary, such as transmission speed, modulation method, and received data quality, for example, as input and generates and outputs transmit digital signal 605. By this means, a terminal transmits a signal containing the radio wave propagation environment when the terminal receives a modulated signal transmitted from the base station, and request information requested by the user or terminal.

[0226]

Also, information generation section 604 receives data 601, radio wave propagation environment information 602, and request information 603 that a user or communication terminal considers necessary, such as transmission speed, modulation method, and received data quality, as input, determines and requests a communication method from radio wave propagation environment information 1401 and 1402 and request information 603, and outputs transmit digital signal 605. At this time, information on the requested communication method is included in transmit digital signal 605. Here, "communication method" is information as to whether communication is performed by means of a multiplex signal and frequency f1 or whether communication is performed by means of a

non-multiplexed signal and frequency f2.

[0227]

The operation of the receiving apparatus and transmitting apparatus of the base station will now be described in detail.

[0228]

FIG. 7 shows one example of the configuration of the receiving apparatus that receives the signal transmitted by, for example, terminal A in the base station. Method determination section 707 extracts radio wave propagation environment information and request information contained in a signal transmitted by the terminal A transmitting apparatus (FIG. 14), or extracts requested communication method information, selects the frequency f1 method whereby signals of a plurality of channels are transmitted from a plurality of antennas, or the frequency f2 method whereby signals of a plurality of channels are not multiplexed and a signal of one channel is transmitted, and outputs this as control signal 708.

[0229]

Frame configuration signal generation section 221 in the base station transmitting apparatus in FIG. 11 receives control signal 708 as input from the receiving apparatus for terminal A, terminal B, terminal C, or terminal D as input control signal 223, and outputs frame configuration signal 222. By this means, modulated signals conforming to the frame configurations in FIG. 8 and FIG. 9 can be transmitted by the base station transmitting apparatus.

[0230]

A description will now be given of the means of setting the communication method at the start of communication.

[0231]

Considering reception quality with respect to the radio wave propagation environment, the quality of channel C information symbols is good in comparison with channel A information symbols and channel B information symbols.

[0232]

Therefore, when a terminal and base station start communicating, the base station maintains data quality by transmitting information to the terminal by channel C information symbols, thereby providing system stability.

[0233]

Alternatively, when a terminal and base station start communicating, the base station first transmits estimation symbols 103 as shown in FIG. 8 and FIG. 9 to the terminal. The terminal then receives the initially transmitted estimation symbols 103, estimates the radio wave propagation environment, and transmits radio wave propagation environment estimation information and request information. Then, based on the radio wave propagation environment information and request information from the terminal, the base station selects either transmission of information by means of channel C information symbols or transmission of information by means of channel A information symbols and channel B information symbols, and starts communication. By this means, data quality can be maintained and therefore system stability is achieved.

[0234]

Alternatively, when a terminal and base station start communicating, the base station first transmits estimation symbols 103

as shown in FIG. 8 and FIG. 9 to the terminal, the terminal receives the initially transmitted estimation symbols 103, estimates the radio wave propagation environment, takes radio wave propagation environment estimation information and request information into consideration, selects either transmission of information by means of channel C information symbols or transmission of information by means of channel A information symbols and channel B information symbols, and makes a request to the base station. Based on the request from the terminal, the base station selects either transmission of information by means of channel C information symbols or transmission of information by means of channel A information symbols and channel B information symbols, and starts communication. By this means, data quality can be maintained and therefore system stability is achieved.

[0235]

In the above description, in FIG. 8, the use of multiplex frames on two channels is illustrated, but the present invention is not limited to this. Also, in FIG. 10, an example with two frequency bands is illustrated, but the present invention is not limited to this. For example, it is possible for there to be three frequency bands, and for frequencies to be assigned for 3-channel multiplex transmission, 2-channel multiplex transmission, and single-channel transmission. A description has been given above that refers to a configuration with two antennas transmitting two channels and one antenna transmitting one channel in the transmitting apparatus in FIG. 11, but the present invention is not limited to this, and two or more antennas may be provided for transmitting two channels. Also, in the case where there are three frequency bands, and frequencies are assigned for 3-channel

multiplex transmission, 2-channel multiplex transmission, and single-channel transmission, it is also possible to provide a plurality of antennas for 3-channel multiplex transmission, to provide a plurality of antennas for 2-channel multiplex transmission, and to provide a plurality of antennas for single-channel transmission. The same applies to the receiving apparatus in FIG. 13. Furthermore, an example has been described in which OFDM is used as the communication method, but it is possible to implement the present invention similarly with either a multicarrier method or a single-carrier method. Moreover, a spread spectrum communication method may be used as the method for each carrier in a multicarrier system. Thus, it is possible to implement the present invention similarly with OFDM-CDM (Orthogonal Frequency Division Multiplex - Code Division Multiplex).

[0236]

Furthermore, there are also cases where one antenna is composed of a plurality of antennas.

[0237]

Thus, when a base station performs communication with a plurality of terminals, by assigning a non-multiplexed frequency in base station transmit frames in communication with a terminal whose reception status is poor, and assigning a multiplexed frequency in communication with a terminal whose reception quality is good, it is possible for a terminal to achieve compatibility between data transmission speed and received data quality.

[0238]

(Embodiment 5)

In Embodiment 5, a description is given of a transmitting apparatus that transmits a non-multiplexed time modulated signal and a multiplexed time modulated signal in transmit frames, and a receiving apparatus that can demodulate either time modulated signals .

[0239]

FIG. 15 shows an example of the frame configuration on the frequency-time axes of channel A and channel B according to this embodiment. Reference numeral 101 indicates a guard symbol, reference numeral 102 indicates an information symbol, reference numeral 103 indicates an estimation symbol, and reference numeral 104 indicates a control symbol. Here, guard symbols 101 are symbols for which there is no modulated signal, estimation symbols 103 are pilot symbols for estimating time synchronization, frequency synchronization, and distortion due to the channel fluctuation, and control symbols 104 are symbols that transmit information used by a terminal for control, and are symbols for transmitting information by means of information symbols 102.

[0240]

In time 3 through time 10, channel A information symbols and channel B information symbols are transmitted, and in time 11 through time 18, only channel A information symbols are transmitted.

[0241]

FIG. 2 shows one example of the configuration of the transmitting apparatus according to this embodiment, as described above.

[0242]

FIG. 16 shows an example of the configuration of a receiving apparatus according to Embodiment 5. Parts in FIG. 16 identical to

those in FIG. 3 are assigned to the same reference numerals as in FIG. 3.

[0243]

Signal processing section 321 receives parallel signals 306 and 316, channel A channel distortion parallel signals 308 and 318, and channel B channel distortion parallel signals 310 and 320, as input separates them into channel A parallel signal 1601 and channel B parallel signal 1604 of the time in which channel A and channel B in FIG. 1 are multiplexed, and outputs them.

[0244]

Channel A demodulation section 1602 receives as input and demodulates separated channel A parallel signal 1601, and outputs a channel A received digital signal 1603.

[0245]

Channel B demodulation section 1605 receives as input and demodulates separated channel B parallel signal 1604, and outputs a channel B received digital signal 1606.

[0246]

Selection section 328 receives parallel signals 306 and 316 as input, selects the parallel signal with the greater field strength, for example, of the times of only channel A signal in FIG. 1, and outputs it as a selected parallel signal 1607.

[0247]

Channel A demodulation section 1608 receives selected parallel signal 1607 as input, and outputs a channel A received digital signal 1609.

[0248]

Using FIG. 2, FIG. 15, and FIG. 16, the operation of the transmitting apparatus and the receiving apparatus according to this embodiment will be described in detail.

[0249]

The operation of the transmitting apparatus will now be described.

[0250]

Channel A serial/parallel conversion section 202 receives channel A transmit digital signal 201 and frame configuration signal 222 as input and outputs channel A parallel signal 203 so that information symbols, control symbols, and estimation symbols are present, as in the channel A frame configuration in FIG. 15.

[0251]

Channel B serial/parallel conversion section 212 receives channel B transmit digital signal 211 and frame configuration signal 222 as input and outputs channel B parallel signal 213 with time 1 estimation symbols 102 and time 3 through 10 information symbols 102 according to the channel B frame configuration in FIG. 15.

[0252]

Estimation symbols 103 are inserted for time synchronization and frequency offset estimation. They are also used for signal separation in frames in which channel A and channel B symbols are multiplexed.

[0253]

When time 11 through 18 channel A information symbols and time 3 through 10 channel A and channel B information symbols are compared, in the receiving apparatus, time 11 through 18 channel A information symbols are of better quality than time 3 through 10 channel A and channel B information symbols. Considering this fact,

it is appropriate for information of high importance to be transmitted by means of time 11 through 18 channel A information symbols.

[0254]

It is possible to transmit one kind of information medium by means of time 11 through 18 channel A information symbols, and transmit one kind of information medium by means of time 3 through 10 channel A and channel B information symbols, such as transmitting video information by means of time 11 through 18 channel A information symbols, and transmitting Hi-Vision video by means of time 3 through 10 channel A and channel B information symbols. Also, the same kind of information medium may be transmitted in time 11 through 18 channel A information symbol transmission and time 3 through 10 channel A and channel B information symbol transmission. At this time, the compression ratio when coding, for example, will be different for the same kind of information.

[0255]

It is also possible to transmit information in a hierarchical fashion, with a certain kind of information transmitted by means of time 11 through 18 channel A information symbols, and difference information transmitted by means of time 3 through 10 channel A and channel B information symbols.

[0256]

The operation of the receiving apparatus is explained.

[0257]

Synchronization section 334 detects estimation symbols 103 in FIG. 15 of received quadrature baseband signal 304 and received signal 314, whereby the receiving apparatus can be synchronized with the

transmitting apparatus.

[0258]

Frequency offset estimation section 332 can estimate the frequency offset from estimation symbols 103 in FIG. 15 in parallel signal 306 and 316.

[0259]

Signal processing section 321 separates time 3 through 10 channel A and channel B information symbol multiplexed signals in FIG. 15 into a time 3 through 10 channel A signal and a time 3 through 10 channel B signal, and outputs the resulting signals as channel A parallel signal 1601 and channel B parallel signal 1604 respectively.

[0260]

Channel A demodulation section 1602 receives channel A parallel signal 1601 as input, and outputs channel A received digital signal 1603. Channel B demodulation section 1605 has channel B parallel signal 1604 as input, and outputs channel B received digital signal 1606.

[0261]

Channel A demodulation section 1608 receives selected parallel signal 1607 as input, estimates channel distortion from estimation symbols 103 in FIG. 15, demodulates the time 11 through 18 channel A parallel signal from the estimated channel distortion, and outputs received digital signal 1609.

[0262]

At this time, received digital signals 1603 and 1606 obtained from channel A and channel B are of poor quality in comparison with channel A received digital signal 1609, but can be transmitted at high

speed. Considering this fact, channel A received digital signal 1609 is suitable for transmission of important information and transmission of control information. Received digital signals 1603 and 1606 obtained from channel A and channel B are input to a decoder X, and decoded. Then channel A received digital signal 1609 is input to a decoder Y, and decoded. By this means, different information X and Y can be obtained from different decoders X and Y, and although the information is the same in decoders X and Y, it is possible to transmit information with different compression ratios.

[0263]

It is possible to perform hierarchical transmission in which video is transmitted by means of channel A received digital signal 1609 and difference information for Hi-Vision video is transmitted by received digital signals 1603 and 1606 obtained from channel A and channel B.

[0264]

In FIG. 2, FIG. 15, and FIG. 16, the use of multiplex frames and non-multiplexed frames with two channels and two antennas has been illustrated as an example, but the present invention is not limited to this. For example, it is possible to implement the present invention similarly with multiplex frames using three channels and three antennas, multiplex frames using two channels and two of three antennas, and frames that cause the existence of non-multiplexed frames. Also, the frame configurations are not limited to those in FIG. 1. Furthermore, an example has been described in which OFDM is used as the communication method, but it is possible to implement the present invention similarly with either a multicarrier method or a single-carrier method. Moreover, a spread spectrum communication method may be

used as the method for each carrier in a multicarrier system. Thus, it is possible to implement the present invention similarly with OFDM-CDM (Orthogonal Frequency Division Multiplex - Code Division Multiplex).

[0265]

Furthermore, there are also cases where one antenna is composed of a plurality of antennas.

[0266]

Thus, by having frames whereby a plurality of modulated signals are transmitted from a plurality of antennas and frames whereby a modulated signal is transmitted from one antenna, and transmitting important information by means of a modulated signal transmitted from one antenna, it is possible to secure data quality in a receiving apparatus. Also, by transmitting different information with frames whereby a plurality of modulated signals are transmitted from a plurality of antennas and frames whereby a modulated signal is transmitted from one antenna, it is possible to transmit information with different qualities and different transmission speeds.

[0267]

(Embodiment 6)

In Embodiment 6, a description is given of a communication method, transmitting apparatus, and receiving apparatus whereby, when a base station performs communication with a plurality of terminals, non-multiplexed frames and multiplexed frames are provided in base station transmit frames, and a modulated signal is transmitted to a terminal using one or other of these types of frame.

[0268]

FIG. 2 shows one example of the configuration of the transmitting apparatus of the base station according to this embodiment, FIG. 4 shows one example of the arrangement state of the base station and the terminal according to this embodiment, FIG. 6 shows one example of the configuration of the transmitting apparatus of the terminal according to this embodiment, FIG. 7 shows one example of the configuration of the receiving apparatus of the base station, FIG. 15 shows one example of the frame configuration of the base station transmit signal according to this embodiment, and the operation is described above.

[0269]

FIG. 17 shows an example of the configuration of a receiving apparatus of a terminal according to Embodiment 6. Parts in FIG. 17 identical to those in FIG. 3 or FIG. 16 are assigned to the same reference numerals as in FIG. 3 or FIG. 16.

[0270]

A radio wave propagation environment estimation section 1701 receives parallel signals 306 and 316 as input, estimates the field strength, multipath environment, Doppler frequency, direction of arrival, channel fluctuation, interference intensity, polarized wave state, and delay profile of received signals received by antenna 301 and the field strength, multipath environment, Doppler frequency, direction of arrival, channel fluctuation, interference intensity, polarized wave state, and delay profile of received signals received by antenna 311, and outputs this information as radio wave propagation environment information to 1702.

[0271]

Using FIG. 2, FIG. 4, FIG. 6, FIG. 7, FIG. 15, and FIG. 17, the communication method among the base station and the terminals according to this embodiment is explained in detail.

[0272]

It is assumed that the locations of the base station and terminals are as shown in FIG. 4. At this time, the reception status of terminal A 402 and terminal B 403 located far from base station 401 is poor, while the reception status of terminal C 404 and terminal D 405 is good as they are near base station 401. Considering this, it is assumed that assignment is performed to communication terminals as shown in FIG. 15 in time-unit or frequency-unit, for example. For example, in channel A and channel B, time 3 through time 6 are assigned for communication with terminal C and time 7 through time 10 are assigned for communication with terminal D. Alternatively, in channel A and channel B, carrier 1 through carrier 3 are assigned for communication with terminal C and carrier 4 through carrier 6 are assigned for communication with terminal D. At this time, communication is performed on channel A and channel B, so that the transmission speed is high.

[0273]

Then, assignment is performed to terminal A 402 and terminal B 403, for which the reception status is poor, as shown in FIG. 15 in time-unit or frequency-unit. For example, in channel A, time 11 through time 14 are assigned for communication with terminal A and time 15 through time 18 are assigned for communication with terminal B. Alternatively, in channel A, carrier 1 through carrier 3 are assigned for communication with terminal A and carrier 4 through

carrier 6 are assigned for communication with terminal B. At this time, communication is performed on only channel A, so that the transmission speed is low but received data quality is good.

[0274]

At this time, by transmitting information concerning channel assignment by means of control symbols 104 in FIG. 15, and having a terminal demodulate control symbols 104, it is possible to ascertain where in a frame information for that terminal is assigned.

[0275]

Next, the receiving apparatus and the transmitting apparatus of the terminal are explained in detail.

[0276]

FIG. 17 shows one example of the configuration of the receiving apparatus of the terminal. A radio wave propagation environment estimation section 1701 receives parallel signals 306 and 316 as input, estimates the field strength, multipath environment, Doppler frequency, direction of arrival, channel fluctuation, interference intensity, polarized wave state, and delay profile of received signals received by antenna 301 and of received signals received by antenna 311 by means of estimation symbols 103 in FIG. 15, and outputs this information as radio wave propagation environment information 1702.

[0277]

FIG. 6 shows one example of the configuration of the transmitting apparatus of the terminal. Radio wave propagation environment information 1702 estimated by radio wave propagation environment estimation section 1701 of the receiving apparatus in FIG. 17 corresponds to radio wave propagation environment information 602,

and is input to information generation section 604.

[0278]

Information generation section 604 receives data 601, radio wave propagation environment information 602, and request information 603 that a user or communication terminal considers necessary, such as transmission speed, modulation method, and received data quality, for example, as input, and generates and outputs transmit digital signal 605. By this means, a terminal transmits a signal containing the radio wave propagation environment when the terminal receives a modulated signal transmitted from the base station, and request information requested by the user or terminal.

[0279]

Also, as the operation different from this, information generation section 604 receives data 601, radio wave propagation environment information 602, and request information 603 that a user or communication terminal considers necessary, such as transmission speed, modulation method, and received data quality, as input, determines and requests a communication method from radio wave propagation environment information 602 and request information 603, and outputs transmit digital signal 605. At this time, information on the requested communication method is included in transmit digital signal 605. Here, "communication method" is information as to whether communication is performed by means of a multiplex signal or whether communication is performed by means of a non-multiplexed signal.

[0280]

Next, the transmitting apparatus and the receiving apparatus of the

base station are explained in detail.

[0281]

FIG. 7 shows one example of the configuration of the receiving apparatus that receives the signal transmitted from the terminal A, for example. Method determination section 707 extracts radio wave propagation environment information and request information contained in a signal transmitted by the terminal A transmitting apparatus (FIG. 6), or extracts requested communication method information, selects either a method whereby signals of a plurality of channels are transmitted from a plurality of antennas or a method whereby signals of a plurality of channels are not multiplexed and a signal of one channel is transmitted, and outputs this information as control signal 708.

[0282]

Frame configuration signal generation section 221 in the base station transmitting apparatus in FIG. 2 receives control signal 708 from a terminal A, terminal B, terminal C, or terminal D receiving apparatus as input control signal 223, and outputs frame configuration signal 222. By this means, modulated signals conforming to the frame configurations in FIG. 15 can be transmitted by the base station transmitting apparatus.

[0283]

A description will now be given of the means of setting the communication method at the start of communication.

[0284]

Considering reception quality with respect to the radio wave propagation environment, the quality of time 11 through 18 channel A

information symbols is good in comparison with time 3 through 10 channel A information symbols and channel B information symbols.

[0285]

Therefore, when a terminal and base station start communicating, the base station maintains data quality by transmitting information to the terminal by means of time 11 through 18 channel A information symbols, thereby providing system stability.

[0286]

Alternatively, when a terminal and base station start communicating, the base station first transmits estimation symbols 103 as shown in FIG. 15 to the terminal, the terminal receives the initially transmitted estimation symbols 103, estimates the radio wave propagation environment, and transmits radio wave propagation environment estimation information and request information. Then, based on the radio wave propagation environment information and request information from the terminal, the base station selects either transmission of information by means of time 11 through 18 channel A information symbols or transmission of information by means of time 3 through 10 channel A information symbols and channel B information symbols, and starts communication. By this means, data quality can be maintained and therefore system stability is achieved.

[0287]

Alternatively, when a terminal and base station start communicating, the base station first transmits estimation symbols 103 as shown in FIG. 8 and FIG. 9 to the terminal, the terminal receives the initially transmitted estimation symbols 103, estimates the radio wave propagation environment, takes radio wave propagation environment

estimation information and request information into consideration, selects either transmission of information by means of time 11 through 18 channel A information symbols or transmission of information by means of time 3 through 10 channel A information symbols and channel B information symbols, and makes a request to the base station. Based on the request from the terminal, the base station selects either transmission of information by means of time 11 through 18 channel A information symbols or transmission of information by means of time 3 through 10 channel A information symbols and channel B information symbols, and starts communication. By this means, data quality can be maintained and therefore system stability is achieved.

[0288]

In FIG. 2, FIG. 15, and FIG. 17, the use of multiplex frames and non-multiplexed frames with two channels and two antennas has been illustrated as an example, but the present invention is not limited to this. For example, it is possible to implement the present invention similarly with multiplex frames using three channels and three antennas, multiplex frames using two channels and two of three antennas, and frames that cause the existence of non-multiplexed frames. Also, the frame configurations are not limited to those in FIG. 1. Furthermore, an example has been described in which OFDM is used as the communication method, but it is possible to implement the present invention similarly with a multicarrier method with regard to time-unit and frequency-unit assignment, or a single-carrier method with regard to time-unit assignment. Moreover, a spread spectrum communication method may be used as the method for each carrier in a multicarrier system. Thus, it is possible to implement the present invention

similarly with OFDM-CDM.

[0289]

Furthermore, there are also cases where one antenna is composed of a plurality of antennas.

[0290]

Thus, when a base station performs communication with a plurality of terminals, by assigning a non-multiplexed frame in base station transmit frames in communication with a terminal whose reception status is poor, and assigning a multiplexed frame in communication with a terminal whose reception quality is good, it is possible for a terminal to achieve compatibility between data transmission speed and data transmission quality.

[0291]

(Embodiment 7)

In Embodiment 7, a description is given of coding and pilot symbol configuration methods in a communication method whereby modulated signals of a plurality of channels are transmitted from a plurality of antennas at the same frequency, and an associated transmitting apparatus and receiving apparatus.

[0292]

FIG. 18 shows an example of the transmit signal frame configuration transmitted by a base station according to Embodiment 7. Parts in FIG. 18 identical to those in FIG. 1 are assigned the same reference numerals as in FIG. 1.

[0293]

In this case, pilot symbols 1801 are inserted in a regular manner in a channel A. After separating a channel A signal and a channel B

signal, channel A information symbols 102 can be demodulated by estimating channel A frequency offset and channel distortion by means of these pilot symbols 1801.

[0294]

At this time, pilot symbols are not inserted in a channel B signal. Performing coding on channel A or making a channel A signal a pilot at this time makes it possible to demodulate channel B information symbols 102.

[0295]

FIG. 19 shows an example of the configuration of a transmitting apparatus according to Embodiment 7. Parts in FIG. 19 identical to those in FIG. 2 are assigned to the same reference numerals as in FIG. 2.

[0296]

A coding section 1901 receives channel A transmit digital signal 201 and channel B transmit digital signal 211 as input, codes channel B transmit digital signal 211 on the basis of channel A transmit digital signal 201, and outputs a post-coding transmit digital signal 1902.

[0297]

Then serial/parallel conversion section 212 receives post-coding transmit digital signal 1902 as input, and outputs post-conversion parallel signal 213.

[0298]

FIG. 20 shows an example of the configuration of a receiving apparatus according to Embodiment 7. Parts in FIG. 20 identical to those in FIG. 3 are assigned the same reference numerals as in FIG. 3.

[0299]

Channel A demodulation section 2003 receives separated channel A parallel signal 2001 as input, and outputs a channel A received digital signal 2004.

[0300]

Channel B demodulation section 2005 receives separated channel A parallel signal 2001 and separated channel B parallel signal 2002 as input, demodulates separated channel B parallel signal 2002 using separated channel A parallel signal 2001, and outputs a channel B received digital signal 2006.

[0301]

FIG. 21 shows one example of the signal point arrangement in the I-Q plane when a channel B signal undergoes differential encoding with respect to a channel A signal. In this case, channel A and channel B signals are subjected to QPSK (Quadrature Phase Shift Keying) modulation.

[0302]

The signal point when information '00' is transmitted in channel A carrier 1 time 4 is positioned as shown in FIG. 21(a). At this time, differential encoding is performed for channel B carrier 1 time 4 with respect to channel A carrier 1 time 4, and therefore when information '00', '01', '11', and '10' is transmitted, the signal points are positioned as shown in FIG. 21(b).

[0303]

Similarly, the signal point when information '01' is transmitted in channel A carrier 1 time 4 is positioned as shown in FIG. 21(c). At this time, differential encoding is performed for channel B carrier 1 time 4 with respect to channel A carrier 1 time 4, and therefore when

information '00', '01', '11', and '10' is transmitted, the signal points are positioned as shown in FIG. 21(d).

[0304]

Similarly, the signal point when information '11' is transmitted in channel A carrier 1 time 4 is positioned as shown in FIG. 21(e). At this time, differential encoding is performed for channel B carrier 1 time 4 with respect to channel A carrier 1 time 4, and therefore when information '00', '01', '11', and '10' is transmitted, the signal points are positioned as shown in FIG. 21(f).

[0305]

Similarly, the signal point when information '10 is transmitted in channel A carrier 1 time 4 is positioned as shown in FIG. 21(g). At this time, differential encoding is performed for channel B carrier 1 time 4 with respect to channel A carrier 1 time 4, and therefore when information '00', '01', '11', and '10' is transmitted, the signal points are positioned as shown in FIG. 21(h).

[0306]

FIG. 22 shows one example of the signal point arrangement in the I-Q plane when a channel B signal undergoes differential encoding with respect to a channel A signal. In this case, channel A and channel B signals are subjected to BPSK modulation.

[0307]

The signal point when information '1' is transmitted in channel A carrier 1 time 4 is positioned at 2201 as shown in FIG. 22(a). At this time, differential encoding is performed for channel B carrier 1 time 4 with respect to channel A carrier 1 time 4, and therefore when information '0' is transmitted, the signal point is positioned at 2202 as

shown in FIG. 22(b), and when information '1' is transmitted, the signal point is positioned at 2203.

[0308]

In contrast to this, the signal point when information '0' is transmitted in channel A carrier 1 time 4 is positioned at 2204 as shown in FIG. 22(c). At this time, differential encoding is performed for channel B carrier 1 time 4 with respect to channel A carrier 1 time 4, and therefore when information '0' is transmitted, the signal point is positioned at 2206 as shown in FIG. 22(d), and when information '1' is transmitted, the signal point is positioned at 2205.

[0309]

FIG. 23 shows one example in which channel B multivalued modulation (here, QPSK modulation) I-Q plane signal point arrangement is performed based on channel A PSK modulation (here, BPSK (Binary Phase Shift Keying) modulation). The channel A and channel B modulation methods are assumed to be different at this time. Another feature is that the channel A modulation method is PSK modulation.

[0310]

The signal point when information '0' is transmitted in channel A carrier 1 time 4 is positioned as shown in FIG. 23(a). At this time, for channel B carrier 1 time 4, the signal point arrangement for information '00', '01', '11', and '10' is determined with respect to the channel A carrier 1 time 4 signal point position. The signal point arrangement at this time is as shown in FIG. 23(b).

[0311]

Similarly, the signal point when information '1' is transmitted in

channel A carrier 1 time 4 is positioned as shown in FIG. 23(c). At this time, for channel B carrier 1 time 4, the signal point arrangement for information '00', '01', '11', and '10' is determined with respect to the channel A carrier 1 time 4 signal point position. The signal point arrangement at this time is as shown in FIG. 23(d).

[0312]

FIG. 24 shows one example in which channel B multivalued modulation (here, 16QAM (16 Quadrature Amplitude Modulation)) I-Q plane signal point arrangement is performed based on channel A PSK modulation (here, BPSK modulation). In this case, the channel A and channel B modulation methods are assumed to be different. Another feature is that the channel A modulation method is PSK modulation.

[0313]

The signal point when information '0' is transmitted in channel A carrier 1 time 4 is positioned as shown in FIG. 24(a). At this time, for channel B carrier 1 time 4, the signal point arrangement for 4-bit information '0000', ..., '1111' is determined with respect to channel A carrier 1 time 4 signal point arrangement . The signal point arrangement at this time is as shown in FIG. 24(b).

[0314]

Similarly, the signal point when information '1' is transmitted in channel A carrier 1 time 4 is positioned as shown in FIG. 24(c). At this time, for channel B carrier 1 time 4, the signal point arrangement for 4-bit information '0000', ..., '1111' is determined with respect to channel A carrier 1 time 4 signal point arrangement . The signal point arrangement at this time is as shown in FIG. 24(d).

[0315]

FIG. 25 shows one example in which channel B multivalued modulation (here, 16QAM) I-Q plane signal point arrangement is performed based on channel A PSK modulation (here, QPSK modulation). The channel A and channel B modulation methods are assumed to be different at this time. Another feature is that the channel A modulation method is PSK modulation.

[0316]

When information '00' is transmitted in channel A carrier 1 time 4, for channel B carrier 1 time 4 the signal point arrangement for 4-bit information '0000', ..., '1111' is determined with respect to channel A carrier 1 time 4 signal point arrangement. The signal point arrangement at this time is as shown in FIG. 25(a).

[0317]

When information '01' is transmitted in channel A carrier 1 time 4, for channel B carrier 1 time 4 the signal point arrangement for 4-bit information '0000', ..., '1111' is determined with respect to channel A carrier 1 time 4 signal point arrangement. The signal point arrangement at this time is as shown in FIG. 25(b).

[0318]

When information '11' is transmitted in channel A carrier 1 time 4, for channel B carrier 1 time 4 the signal point arrangement for 4-bit information '0000', ..., '1111' is determined with respect to channel A carrier 1 time 4 signal point arrangement. The signal point arrangement at this time is as shown in FIG. 25(c).

[0319]

When information '10' is transmitted in channel A carrier 1 time 4, for channel B carrier 1 time 4 the signal point arrangement for 4-bit

information '0000', ..., '1111' is determined with respect to channel A carrier 1 time 4 signal point arrangement. The signal point arrangement at this time is as shown in FIG. 25(d).

[0320]

FIG. 26 shows an example of base station transmit signal frame configurations of this embodiment. Parts in FIG. 26 identical to those in FIG. 1 or FIG. 18 are assigned to the same reference numerals as in FIG. 1 or FIG. 18.

[0321]

In FIG. 26, pilot symbols 1801 are inserted in a regular fashion in both channel A and channel B.

[0322]

At this time, estimation symbols 103 are symbols used by the receiver to separate channel A and channel B, and channel A pilot symbols 1801 are symbols for estimating channel A signal channel distortion, frequency offset, and suchlike distortion components in the channel A demodulation section after channel A and channel B signal separation in the receiver. Similarly, channel B pilot symbols 1801 are symbols for estimating channel B signal channel distortion, frequency offset, and suchlike distortion components in the channel B demodulation section after channel A and channel B signal separation in the receiver.

[0323]

In FIG. 26, estimation symbols 103 for when channel A and channel B signal separation is performed are not multiplexed in channel A and channel B. Another feature is that aforementioned pilot symbols 1801 are multiplexed.

[0324]

FIG. 2 shows one example of the configuration of the transmitting apparatus according to this embodiment.

[0325]

FIG. 27 shows an example of pilot symbol signal point arrangement in the I-Q plane according to this embodiment.

[0326]

Reference numeral 2701 indicates a known pilot symbol, and denotes signal point positioning at a specific location.

[0327]

Reference numeral 2702 indicates known BPSK pilot symbols, which are BPSK modulated and positioned in a regular fashion.

[0328]

FIG. 28 shows an example of base station transmit signal frame configurations according to this embodiment. Parts in FIG. 28 identical to those in FIG. 1 are assigned the same reference numerals as in FIG. 1.

[0329]

In FIG. 28, a feature is that pilot symbols are not inserted for estimating channel distortion, frequency offset, and suchlike distortion after channel A and B separation. Another feature is that the channel A modulation method is PSK modulation.

[0330]

At this time, channel A undergoes differential encoding on the frequency axis or time axis.

[0331]

Then in channel B, information bits are assigned for channel A

signal point arrangement.

[0332]

FIG. 29 shows an example of the configuration of a receiving apparatus according to this embodiment. Parts in FIG. 29 identical to those in FIG. 3 are assigned to the same reference numerals as in FIG. 3.

[0333]

Channel A demodulation section 2903 receives a separated channel A parallel signal 2901 as input, demodulates a channel A signal, and outputs a channel A received digital signal 2904.

[0334]

Channel B demodulation section 2905 receives a separated channel B parallel signal 2902 as input, demodulates a channel B signal, and outputs a channel B received digital signal 2906.

[0335]

FIG. 30 shows the configuration of the channel B demodulation section as an example of the configuration of channel A and channel B demodulation sections according to this embodiment.

[0336]

A channel distortion estimation section 3002 receives a channel B parallel signal 3001 as input, estimates channel distortion, and outputs a channel distortion estimation signal 3003.

[0337]

A frequency offset estimation section 3004 receives channel B parallel signal 3001 as input, estimates frequency offset, and outputs a frequency offset estimation signal 3005.

[0338]

Information symbol demodulation section 3006 receives as input and demodulates channel B parallel signal 3001, channel distortion estimation signal 3003, and frequency offset estimation signal 3005 and outputs a received digital signal 3007.

[0339]

FIG. 31 shows the configuration of the channel B demodulation section as an example of the configuration of channel A and channel B demodulation sections according to this embodiment.

[0340]

A channel distortion estimation section 3102 receives a channel A parallel signal 3108 as input, estimates channel distortion, and outputs a channel distortion estimation signal 3103.

[0341]

A frequency offset estimation section 3104 receives channel A parallel signal 3108 as input, estimates frequency offset, and outputs a frequency offset estimation signal 3105.

[0342]

Information symbol demodulation section 3106 receives as input and demodulates channel B parallel signal 3101, channel distortion estimation signal 3103, and frequency offset estimation signal 3105, and outputs a channel B received digital signal 3107.

[0343]

FIG. 32 shows the configuration of the channel B demodulation section as an example of the configuration of channel A and channel B demodulation sections according to this embodiment.

[0344]

A channel distortion estimation section 3202 receives a channel B

parallel signal 3201 and channel A parallel signal 3208 as input, estimates channel distortion, and outputs a channel distortion estimation signal 3203.

[0345]

A frequency offset estimation section 3204 receives channel B parallel signal 3201 and channel A parallel signal 3208 as input, estimates frequency offset, and outputs a frequency offset estimation signal 3205.

[0346]

Information symbol demodulation section 3206 receives as input and demodulates channel B parallel signal 3201, channel distortion estimation signal 3203, and frequency offset estimation signal 3205, and outputs a channel B received digital signal 3207.

[0347]

FIG. 33 shows the configuration of the channel B demodulation section as an example of the configuration of channel A and channel B demodulation sections according to this embodiment.

[0348]

An information symbol demodulation section 3303 receives as input and demodulates a channel A parallel signal 3302 and a channel B parallel signal 3301, and outputs a channel B received digital signal 3304.

[0349]

FIG. 34 shows an example of the configuration of a receiving apparatus according to this embodiment. Parts in FIG. 34 identical to those in FIG. 3 or FIG. 29 are assigned to the same reference numerals as in FIG. 3 or FIG. 29.

[0350]

Features of FIG. 34 are that separated channel A parallel signal 2901 and separated channel B parallel signal 2902 are input to channel A demodulation section 2903, and that channel A demodulation is performed by means of separated channel A parallel signal 2901 and separated channel B parallel signal 2902.

[0351]

Similarly, features are that separated channel A parallel signal 2901 and separated channel B parallel signal 2902 are input to channel B demodulation section 2905, and that channel B demodulation is performed by means of separated channel A parallel signal 2901 and separated channel B parallel signal 2902.

[0352]

FIG. 35 shows the configuration of the channel B demodulation section as an example of the configuration of channel A and channel B demodulation sections according to this embodiment. Parts in FIG. 35 identical to those in FIG. 32 are assigned to the same reference numerals as in FIG. 32.

[0353]

Using FIG. 18, FIG. 19, FIG. 20, FIG. 21, FIG. 22, FIG. 23, FIG. 24, FIG. 25, FIG. 27, FIG. 28, FIG. 30, FIG. 31, FIG. 33, and FIG. 35, the communication method of encoding the signal of channel B based on the signal of channel A and the transmitting apparatus and the receiving apparatus using the communication method are explained.

[0354]

Explanations are given of the case in which channel A and channel B are differentially encoded.

[0355]

FIG. 18 is one example of the frame configuration of the base station transmit signal according to this embodiment. In this case, pilot symbols 1801 are inserted in a regular manner in a channel A signal. In this case, both estimation symbols 103 and pilot symbols 1801 are, for example, known symbols (known pilots). However, their roles differ in the receiver. Estimation symbols 103 are used to perform signal processing that separates multiplexed signals in channel A and channel B. On the other hand, channel B pilot symbols 1801 are signals to be references for demodulating channel A signals after separation, and are symbols for, for example, estimating phase, amplitude, channel distortion, and frequency offset in the I-Q plane.

[0356]

Next, the relationship between channel A and channel B is explained.

[0357]

For example, FIG. 21 shows one example of the relationship between channel A and channel B when both perform the QPSK modulation.

[0358]

In channel A, two bits transmitted by one information symbol are as shown in (a), (b), (c), and (d) in FIG. 21.

[0359]

Then, channel B is differentially encoded in accordance with the channel A signal. For example, explanations are given of the relationship between channel A carrier 1 time 4 and channel B carrier 1 time 4 in the frame configuration in FIG. 18.

[0360]

The signal point when information '00' is transmitted in channel A carrier 1 time 4 is positioned as shown in FIG. 21(a). At this time, differential encoding is performed for channel B carrier 1 time 4 with respect to channel A carrier 1 time 4, and therefore when information '00', '01', '11', and '10' is transmitted, the signal points are positioned as shown in FIG. 21(b).

[0361]

Similarly, the signal point when information '01' is transmitted in channel A carrier 1 time 4 is positioned as shown in FIG. 21(c). At this time, differential encoding is performed for channel B carrier 1 time 4 with respect to channel A carrier 1 time 4, and therefore when information '00', '01', '11', and '10' is transmitted, the signal points are positioned as shown in FIG. 21(d).

[0362]

Similarly, the signal point when information '11' is transmitted in channel A carrier 1 time 4 is positioned as shown in FIG. 21(e). At this time, differential encoding is performed for channel B carrier 1 time 4 with respect to channel A carrier 1 time 4, and therefore when information '00', '01', '11', and '10' is transmitted, the signal points are positioned as shown in FIG. 21(f).

[0363]

Similarly, the signal point when information '10' is transmitted in channel A carrier 1 time 4 is positioned as shown in FIG. 21(g). At this time, differential encoding is performed for channel B carrier 1 time 4 with respect to channel A carrier 1 time 4, and therefore when information '00', '01', '11', and '10' is transmitted, the signal points are

positioned as shown in FIG. 21(h).

[0364]

Then, for example, with symbols of the same carrier and the same time of channel A and channel B, it is assumed that the symbol of channel B is differentially encoded in accordance with the symbol of channel A.

[0365]

Then, FIG. 22 shows one example of the relationship of channel A and channel B when both perform the BPSK modulation is performed in both channel A and channel B.

[0366]

It is assumed that, in channel A, two bits transmitted by one information symbol are shown as (a) and (c) in FIG. 22.

[0367]

Then, channel B is differentially encoded in accordance with the channel A signal. For example, explanations are given of the relationship between channel A carrier 1 time 4 and channel B carrier 1 time 4 in the frame configuration in FIG. 18.

[0368]

The signal point when information '1' is transmitted in channel A carrier 1 time 4 is positioned at 2201 as shown in FIG. 22(a). At this time, differential encoding is performed for channel B carrier 1 time 4 with respect to channel A carrier 1 time 4, and therefore when information '0' is transmitted, the signal point is positioned at 2202 as shown in FIG. 22(b), and when information '1' is transmitted, the signal point is positioned at 2203.

[0369]

In contrast to this, the signal point when information '0' is transmitted in channel A carrier 1 time 4 is positioned at 2204 as shown in FIG. 22(c). At this time, differential encoding is performed for channel B carrier 1 time 4 with respect to channel A carrier 1 time 4, and therefore when information '0' is transmitted, the signal point is positioned at 2206 as shown in FIG. 22(d), and when information '1' is transmitted, the signal point is positioned at 2205.

[0370]

Then, for example, with symbols of the same carrier and the same time of channel A and channel B, it is assumed that the symbol of channel B is differentially encoded in accordance with the symbol of channel A.

[0371]

Next, the transmitting apparatus is explained.

[0372]

FIG. 19 is one example of the configuration of the transmitting apparatus that performs differential encoding in FIG. 21 or FIG. 22 in the frame configuration in FIG. 18.

[0373]

Referring to FIG. 19, explanations are given of parts that are different from the operation of FIG. 2, namely, channel B.

[0374]

In channel B, differential encoding is performed. A coding section 1901 receives channel A transmit digital signal 201 and channel B transmit digital signal 211 as inputs, performs differential coding, like FIG. 21 and FIG. 22, and outputs a post-coding transmit digital signal 1902.

[0375]

Next, the configuration of the receiving apparatus is explained.

[0376]

FIG. 20 is one example of the configuration of the transmitting apparatus that performs differential encoding in FIG. 21 or FIG. 22 in the frame configuration in FIG. 18.

[0377]

Referring to FIG. 20, explanations are given of parts that are different from the operation of FIG. 2.

[0378]

Channel A demodulation section 2003 receives separated channel A parallel signal 2001 as an input, demodulates channel A information symbol 102 in FIG. 18, and outputs a channel A received digital signal 2004. FIG. 30 shows the detailed configuration of channel A demodulation section 2003 at this time.

[0379]

In FIG. 30, channel distortion estimation section 3002 receives channel A parallel signal 3001 corresponding to separated channel A parallel signal 2001 in FIG. 20 as input, extracts pilot symbols 1801, for example, inserted in channel A in FIG. 20, estimates channel distortion, and outputs channel distortion estimation signal 3003.

[0380]

Similarly, frequency offset estimation section 3004 receives channel A parallel signal 3001 as input, extracts pilot symbols 1801, for example, inserted in channel A in FIG. 18, estimates frequency offset, and outputs frequency offset estimation signal 3005.

[0381]

Then, information symbol demodulation section 3006 receives channel A parallel signal 3001, channel distortion estimation signal 3003 and frequency offset estimation signal 3005 as input, eliminates distortion, like frequency offset and channel distortion, performs demodulation, and outputs channel A received digital signal 3007.

[0382]

Channel B demodulation section 2005 receives separated channel A parallel signal 2001 and separated channel B parallel signal 2002 as input, demodulates channel B information symbols 102 in FIG. 18, and outputs channel B received digital signal 2006. Drawings showing the detailed configuration of channel B demodulation section 2005 at this time are FIG. 33 and FIG. 35.

[0383]

In FIG. 33, information symbol demodulation section 3303 receives channel A parallel signal 3302 corresponding to separated channel A parallel signal 2001 in FIG. 20, and channel B parallel signal 3301 corresponding to separated divided channel B parallel signal 2002 in FIG. 20 as input, performs differential detection (differentially coherent detection), and outputs channel B received digital signal 3304.

[0384]

In FIG. 35, channel distortion estimation section 3202 has channel A parallel signal 3208 corresponding to separated channel A parallel signal 2001 in FIG. 20 as input, extracts, for example, channel A pilot symbols 1801 in FIG. 18, estimates channel distortion, and outputs channel distortion estimation signal 3203.

[0385]

Similarly, frequency offset estimation section 3204 receives

channel A parallel signal 3208 corresponding to separated channel A parallel signal 2001 in FIG. 20 as input, extracts, for example, channel A pilot symbols 1801 in FIG. 18, estimates frequency offset, and outputs frequency offset estimation signal 3205.

[0386]

Then, information symbol demodulation section 3206 receives channel A parallel signal 3208, channel B parallel signal 3201, channel distortion estimation signal 3203, and frequency offset estimation signal 3205, as input, eliminates frequency offset, channel distortion, and suchlike distortion, performs differential detection (differentially coherent detection) on the channel B parallel signal and channel A parallel signal, and outputs a channel B received digital signal 3207.

[0387]

The method of differential encoding for channel A and channel B is not limited to this. For example, differential encoding may be performed only for certain specific symbols. Also, it is not necessary for channel A and channel B differentially coded symbols to be symbols of the same carrier or the same time. Furthermore, a description has been given using BPSK and QPSK as examples of differential encoding, but this is not a limitation, and in the case of PSK modulation, in particular, the present invention is easy to implement. The channel used as a reference when performing differential encoding must transmit constantly, and this channel is suitable for the transmission of control information, such as communication conditions and channel configuration information, for example.

[0388]

The above description refers to configurations in FIG. 31 and FIG.

35 in which a channel distortion estimation section and frequency offset estimation section are provided, but the present invention can be similarly implemented with a configuration in which only one or the other is provided.

[0389]

A transmitting apparatus and receiving apparatus are not limited to the configurations in FIG. 19 and FIG. 20. Also, the use of multiplex frames and non-multiplexed frames with two channels and two antennas has been described as an example, but the present invention is not limited to this. For example, it is possible to implement the present invention similarly with multiplex frames using three channels and three antennas, and multiplex frames using two channels and two of three antennas. In this case, when using 3-channel multiplexing, if the additional channel is designated channel C, channel C is differentially coded with channel A. Also, the frame configurations are not limited to those in FIG. 18. Furthermore, an example has been described in which OFDM is used as the communication method, but it is possible to implement the present invention similarly with a multicarrier method, a spread spectrum communication method, or a single-carrier method. Moreover, a spread spectrum communication method may be used as the method for each carrier in a multicarrier system. Thus, it is possible to implement the present invention similarly with OFDM-CDM.

[0390]

Furthermore, there are also cases where one antenna is composed of a plurality of antennas.

[0391]

Thus, a channel B signal undergoes differential encoding by means of a channel A signal, and pilot symbols are not inserted in channel B, with the result that transmission speed is improved compared with a system in which pilot symbols are inserted in channel B.

[0392]

Next, a case will be described in which channel B is coded based on a channel A signal.

[0393]

FIG. 18 is an example of the base station transmit signal frame configuration according to Embodiment 7. In this case, pilot symbols 1801 are inserted in a channel A. At this time, both estimation symbols 103 and pilot symbols 1801 are, for example, known symbols (known pilots). However, their roles differ in the receiver. Estimation symbols 103 are used to perform signal processing that separates multiplexed signals in channel A and channel B. On the other hand, channel B pilot symbols 1801 are signals to be references for demodulating channel A signals after separation, and are symbols for, for example, estimating phase in the I-Q plane, amplitude, channel distortion, and frequency offset.

[0394]

Next, the relationship between the channel A and the channel B is explained.

[0395]

For example, FIG. 23 shows one example of the relationship when channel A undergoes the BPSK modulation and channel B undergoes the QPSK modulation.

[0396]

It is assumed that, in the channel A, one bit to be transmitted by one information symbol is shown as (a) and (c) in FIG. 23.

[0397]

Then, the channel B is encoded in accordance with the channel A signal. For example, explanations are given of the relationship between the channel A carrier 1 time 4 and the channel B carrier 1 time 4 in the frame configuration in FIG. 23.

[0398]

The signal point when information '0' is transmitted in channel A carrier 1 time 4 is positioned as shown in FIG. 23(a). At this time, differential encoding is performed for channel B carrier 1 time 4 with respect to channel A carrier 1 time 4, and therefore when information '00', '01', '11', and '10' is transmitted, the signal points are positioned as shown in FIG. 23(b).

[0399]

Similarly, the signal point when information '1' is transmitted in channel A carrier 1 time 4 is positioned as shown in FIG. 23(c). At this time, differential encoding is performed for channel B carrier 1 time 4 with respect to channel A carrier 1 time 4, and therefore when information '00', '01', '11', and '10' is transmitted, the signal points are positioned as shown in FIG. 23(d).

[0400]

In this way, channel B is encoded in accordance with the signal point of channel A. Then, for example, with symbols of the same carrier and the same time of channel A and channel B, it is assumed that the symbol of channel B is encoded in accordance with the symbol of channel A.

[0401]

As shown in FIG. 23, when channel B is encoded in accordance with channel A, channel A can be used as a pilot symbol for channel B. That is to say, when the channel B signal in the receiver is demodulated, it is possible to estimate frequency offset, channel distortion, and phase in the I-Q plane by using the channel A signal. Therefore, the channel A signal can be used as a pilot symbol for channel B signal.

[0402]

Then, FIG. 24 shows one example of the relationship when channel A undergoes BPSK modulation and channel B undergoes 16QAM.

[0403]

One bit to be transmitted by one information symbol in the channel A is represented by (a) and (c) in FIG. 24.

[0404]

Then, the channel B is encoded in accordance with the channel A signal. For example, explanations are given of the relationship between the channel A carrier 1 time 4 and the channel B carrier 1 time 4 in the frame configuration in FIG. 18.

[0405]

The signal point when information '0' is transmitted in channel A carrier 1 time 4 is positioned as shown in FIG. 24(a). At this time, encoding is performed for channel B carrier 1 time 4 with respect to channel A carrier 1 time 4, and therefore, four bits of information are positioned as shown in FIG. 24(b).

[0406]

Similarly, the signal point when information '1' is transmitted in channel A carrier 1 time 4 is positioned as shown in FIG. 24(c). At

this time, encoding is performed for channel B carrier 1 time 4 with respect to channel A carrier 1 time 4, and therefore four bits of information are positioned as shown in FIG. 24(d).

[0407]

In this way, channel B is encoded in accordance with the signal point of channel A. Then, for example, with symbols of the same carrier and the same time of channel A and channel B, it is assumed that the symbol of channel B is encoded in accordance with the symbol of channel A.

[0408]

As shown in FIG. 24, when channel B is encoded in accordance with channel A, channel A can be used as a pilot symbol for channel B. That is to say, when the channel B signal in the receiver is demodulated, it is possible to estimate frequency offset, channel distortion, and phase in the I-Q plane by using the channel A signal. Therefore, the channel A signal can be used as a pilot symbol for channel B signal.

[0409]

Then, FIG. 25 shows one example of the relationship when channel A undergoes QPSK modulation and channel B undergoes 16QAM.

[0410]

In channel A, two bits transmitted by one information symbol are shown as 2501 in FIG. 25.

[0411]

Then, the channel B is encoded in accordance with the channel A signal. For example, explanations are given of the relationship between the channel A carrier 1 time 4 and the channel B carrier 1 time 4 in the frame configuration in FIG. 18.

[0412]

The signal point when information '00' is transmitted in channel A carrier 1 time 4 is positioned at 2501 in FIG. 25(a). At this time, encoding is performed for channel B carrier 1 time 4 with respect to channel A carrier 1 time 4, and therefore four bits of information are positioned as shown in FIG. 25(a).

[0413]

Similarly, the signal point when information '01' is transmitted in channel A carrier 1 time 4 is positioned at 2501 as shown in FIG. 25(b). At this time, encoding is performed for channel B carrier 1 time 4 with respect to channel A carrier 1 time 4, and therefore four bits of information are arranged as shown in FIG. 25(b).

[0414]

Similarly, the signal point when information '11' is transmitted in channel A carrier 1 time 4 is positioned at 2501 as shown in FIG. 25(c). At this time, encoding is performed for channel B carrier 1 time 4 with respect to channel A carrier 1 time 4, and therefore four bits of information are arranged as shown in FIG. 25(c).

[0415]

Similarly, the signal point when information '10' is transmitted in channel A carrier 1 time 4 is positioned at 2501 as shown in FIG. 25(d). At this time, encoding is performed for channel B carrier 1 time 4 with respect to channel A carrier 1 time 4, and therefore four bits of information are arranged as shown in FIG. 25(d).

[0416]

In this way, channel B is encoded in accordance with the signal point of channel A. Then, for example, with symbols of the same

carrier and the same time of channel A and channel B, it is assumed that the symbol of channel B is encoded in accordance with the symbol of channel A

[0417]

As shown in FIG. 25, when channel B is encoded in accordance with channel A, channel A can be used as a pilot symbol for channel B. That is to say, when the channel B signal in the receiver is demodulated, it is possible to estimate frequency offset, channel distortion, and phase in the I-Q plane by using the channel A signal. Therefore, the channel A signal can be used as a pilot symbol for channel B signal.

[0418]

Next, the transmitting apparatus is explained.

[0419]

FIG. 19 is one example of the configuration of the transmitting apparatus that performs encoding as in FIG. 23, FIG. 24, or FIG. 25 in the frame configuration in FIG. 18.

[0420]

Referring toFIG. 19, explanations are given of parts that are different from the operation of FIG. 2, namely, channel B.

[0421]

In channel B, encoding is performed. A coding section 1901 receives channel A transmit digital signal 201 and channel B transmit digital signal 211 as input, performs coding, like FIG. 23, FIG. 24, and FIG. 25, and outputs a post-coding transmit digital signal 1902.

[0422]

Next, the configuration of the receiving apparatus is explained.

[0423]

FIG. 20 is one example of the configuration of the receiving apparatus that receives the decoded transmit signal as in FIG. 23, FIG. 24, or FIG. 25 in the frame configuration in FIG. 18.

[0424]

Referring to FIG. 20, explanations are given of parts that are different from the operation of FIG. 2.

[0425]

Channel A demodulation section 2003 receives separated channel A parallel signal 2001 as input, demodulates channel A information symbol 102 in FIG. 18, and outputs channel A received digital signal 2004. FIG. 30 shows the detailed configuration of channel A demodulation section 2003 at this time.

[0426]

In FIG. 30, channel distortion estimation section 3002 receives channel A parallel signal 3001 corresponding to separated channel A parallel signal 2001 in FIG. 20 as input, extracts, for example, pilot symbols 1801 inserted in channel A in FIG. 18, estimates channel distortion, and outputs channel distortion estimation signal 3003.

[0427]

Similarly, frequency offset estimation section 3004 receives channel A parallel signal 3001 as input, extracts, for example, pilot symbols 1801 inserted in channel A in FIG. 18, estimates frequency offset, and outputs frequency offset estimation signal 3005.

[0428]

Then, information symbol demodulation section 3006 receives channel A parallel signal 3001, channel distortion estimation signal 3003, and frequency offset estimation signal 3005 as input, eliminates

frequency offset, channel distortion, and suchlike distortion from, performs demodulation, and outputs channel A received digital signal 3007.

[0429]

Channel B demodulation section 2005 receives separated channel A parallel signal 2001 and separated channel B parallel signal 2002 as input, demodulates channel B information symbols 102 in FIG. 18, and outputs channel B received digital signal 2006. A drawing showing the detailed configuration of channel B demodulation section 2005 at this time is FIG. 35.

[0430]

In FIG. 35, channel distortion estimation section 3202 receives channel A parallel signal 3208 corresponding to separated channel A parallel signal 2001 in FIG. 20 as input, extracts, for example, channel A pilot symbols 1801 in FIG. 18, estimates channel distortion, and outputs channel distortion estimation signal 3203.

[0431]

Similarly, frequency offset estimation section 3204 receives channel A parallel signal 3208 corresponding to separated channel A parallel signal 2001 in FIG. 20 as input, extracts, for example, channel A pilot symbols 1801 in FIG. 18, estimates frequency offset, and outputs frequency offset estimation signal 3205.

[0432]

Then, information symbol demodulation section 3206 receives channel A parallel signal 3208, channel B parallel signal 3201, channel distortion estimation signal 3203, and frequency offset estimation signal 3205 as input, eliminates frequency offset, channel distortion,

and suchlike distortion, performs detection on the channel B parallel signal and channel A parallel signal, and outputs a channel B received digital signal 3207.

[0433]

In the above description, the method of encoding for channel A and channel B is not limited to this. For example, encoding may be performed only for certain specific symbols. Also, it is not necessary for channel A and channel B coded symbols to be symbols of the same carrier or the same time. Furthermore, a description has been given using BPSK and QPSK as examples of encoding, but this is not a limitation, and in the case of PSK modulation, in particular, the present invention is easy to implement. The channel used as a reference when performing encoding must transmit constantly, and this channel is suitable for the transmission of control information, such as communication conditions and channel configuration information, for example.

[0434]

The above description refers to configuration in FIG. 35 in which a channel distortion estimation section and frequency offset estimation section are provided, but the present invention can be similarly implemented with a configuration in which only one or the other is provided.

[0435]

A transmitting apparatus and receiving apparatus are not limited to the configurations in FIG. 19 and FIG. 20. Also, the use of multiplex frames and non-multiplexed frames with two channels and two antennas has been described as an example, but the present invention is not

limited to this. For example, it is possible to implement the present invention similarly with multiplex frames using three channels and three antennas, and multiplex frames using two channels and two of three antennas. In this case, when using 3-channel multiplexing, if the additional channel is designated channel C, channel C is coded with channel A. Also, the frame configurations are not limited to those in FIG. 18. Furthermore, an example has been described in which OFDM is used as the communication method, but it is possible to implement the present invention similarly with a multicarrier method, a spread spectrum communication method, or a single-carrier method. Moreover, a spread spectrum communication method may be used as the method for each carrier in a multicarrier system. Thus, it is possible to implement the present invention similarly with OFDM-CDM (Orthogonal Frequency Division Multiplex - Code Division Multiplex).

[0436]

Furthermore, there are also cases where one antenna is composed of a plurality of antennas.

[0437]

Thus, a channel B signal is encoded by a channel A signal and pilot symbols are not inserted in channel B, so that transmission speed is improved compared with a system in which pilot symbols are inserted in channel B.

[0438]

A description will now be given of the method of performing differential encoding of channel A and channel B, and the method of performing channel B signal point arrangement based on a channel A signal point, with the frame configurations in FIG. 28.

[0439]

FIG. 28 is one example of the frame configuration of base station transmit signal according to this embodiment. In this case, channel A is PSK modulated, and is subjected to differential encoding with, for example, an adjacent symbol on the frequency axis or time axis. Consequently, it is not necessary to insert pilot symbols. Then channel A and channel B is differentially encoded as in FIG. 21 or FIG. 22, for example. Alternatively, channel B signal points are arranged on the basis of a channel A signal point as in FIG. 23, FIG. 24, or FIG. 25. By coding in this way, in the receiver it is possible to estimate channel distortion, frequency offset, and phase in the I-Q plane - that is, to make pilot symbols - by means of a channel A signal when a channel B signal is demodulated.

[0440]

FIG. 19 and FIG. 20 show examples of the configurations of a transmitting apparatus and receiving apparatus in this case. At this time, points of difference in operation when transmitting or receiving a frame in FIG. 18 are that, in FIG. 19, channel A transmit digital signal 201 is differentially encoded, and in channel A demodulation section 2003 in FIG. 20, differential detection (delay detection) is performed, and channel A received digital signal 2004 is output.

[0441]

The method of encoding for channel A and channel B is not limited to this. For example, encoding may be performed only for certain specific symbols. Also, it is not necessary for channel A and channel B coded symbols to be symbols of the same carrier or the same time. Furthermore, a description has been given using BPSK and QPSK as

examples of encoding, but this is not a limitation, and in the case of PSK modulation, in particular, the present invention is easy to implement. The channel used as a reference when performing differential encoding must transmit constantly, and this channel is suitable for the transmission of control information, such as communication conditions and channel configuration information, for example.

[0442]

A transmitting apparatus and receiving apparatus are not limited to the configurations in FIG. 19 and FIG. 20. Also, the use of multiplex frames and non-multiplexed frames with two channels and two antennas has been described as an example, but the present invention is not limited to this. For example, it is possible to implement the present invention similarly with multiplex frames using three channels and three antennas, and multiplex frames using two channels and two of three antennas. In this case, when using 3-channel multiplexing, if the additional channel is designated channel C, channel C is coded with channel A. Also, the frame configurations are not limited to those in FIG. 28. Furthermore, an example has been described in which OFDM is used as the communication method, but it is possible to implement the present invention similarly with a multicarrier method, a spread spectrum communication method, or a single-carrier method. Moreover, a spread spectrum communication method may be used as the method for each carrier in a multicarrier system. Thus, it is possible to implement the present invention similarly with OFDM-CDM.

[0443]

Furthermore, there are also cases where one antenna is composed of a plurality of antennas.

[0444]

As described above, channel A is differentially coded on the frequency axis or time axis, a channel B signal is coded by means of a channel A signal, and pilot symbols are not inserted in channel A or channel B, so that transmission speed is improved compared with a system in which pilot symbols are inserted in channel A and channel B.

[0445]

The method of inserting pilot symbols in channel A and channel B will now be described using FIG. 2, FIG. 26, FIG. 29, FIG. 32, and FIG. 34.

[0446]

FIG. 26 is an example of the base station transmit signal frame configuration according to Embodiment 7. In this case, pilot symbols 1801 are inserted in both channel A and channel B. In the case, both estimation symbols 103 and pilot symbols 1801 are, for example, known reference symbols (known pilots). However, their roles differ in the receiver. Estimation symbols 103 are used to perform signal processing that separates channel A and channel B multiplexed signals.

[0447]

Then, when channel A information symbols are demodulated, channel A pilot symbols 1801 and channel B pilot symbols 1801 are used to estimate channel distortion, frequency offset, and phase and amplitude in the I-Q plane.

[0448]

Similarly, when channel B information symbols are demodulated,

channel A pilot symbols 1801 and channel B pilot symbols 1801 are used to estimate channel distortion, frequency offset, and phase and amplitude in the I-Q plane.

[0449]

Next, the transmitting apparatus is explained.

[0450]

FIG. 2 shows one example of the configuration of the transmitting apparatus that transmits the signal of the frame configuration in FIG. 26.

[0451]

The modulated signal is generated by the information of the frame configuration in FIG. 26 contained in the frame configuration signal 222 output from the frame configuration signal generation section 221 in FIG. 2.

[0452]

Next, the configuration of the receiving apparatus is explained.

[0453]

FIG. 34 is an example of the configuration of a receiving apparatus that receives the signal of the frame configuration in FIG. 26.

[0454]

In FIG. 34, the example of the channel A and channel B demodulation sections is as shown in FIG. 32.

[0455]

Here, channel A demodulation section 2903 will be described as an example.

[0456]

Channel distortion estimation section 3202 receives channel A

parallel signal 3201 corresponding to separated channel A parallel signal 2901 in FIG. 34 and channel B parallel signal 3208 corresponding to separated channel B parallel signal 2902 in FIG. 34 as input, extracts pilot symbols 1801 inserted in channel A and pilot symbols 1801 inserted in channel B in FIG. 26, estimates channel distortion, and outputs channel distortion estimation signal 3203.

[0457]

Similarly, frequency offset estimation section 3204 receives channel A parallel signal 3201 corresponding to separated channel A parallel signal 2901 in FIG. 34 and channel B parallel signal 3208 corresponding to separated channel B parallel signal 2902 in FIG. 34 as input, extracts pilot symbols 1801 inserted in channel A and pilot symbols 1801 inserted in channel B in FIG. 26, estimates frequency offset, and outputs frequency offset estimation signal 3206.

[0458]

Then, information symbol demodulation section 3206 receives channel A parallel signal 3201, channel distortion estimation signal 3203, and frequency offset estimation signal 3206 as input, eliminates frequency offset, channel distortion, and suchlike distortion, performs demodulation, and outputs channel A received digital signal 3007.

[0459]

Channel distortion estimation section 3202 receives channel B parallel signal 3201 corresponding to separated channel B parallel signal 2902 in FIG. 34 and channel A parallel signal 3208 corresponding to separated channel A parallel signal 2901 in FIG. 34 as input, extracts pilot symbols 1801 inserted in channel A and pilot symbols 1801 inserted in channel B in FIG.26, estimates channel

distortion, and outputs channel distortion estimation signal 3203.

[0460]

Similarly, frequency offset estimation section 3204 receives channel B parallel signal 3201 corresponding to separated channel B parallel signal 2902 in FIG. 34 and channel A parallel signal 3208 corresponding to separated channel A parallel signal 2901 in FIG. 34 as input, extracts pilot symbols 1801 inserted in channel A and pilot symbols 1801 inserted in channel B in FIG. 26, estimates frequency offset, and outputs frequency offset estimation signal 3206.

[0461]

Then, information symbol demodulation section 3206 receives channel B parallel signal 3201, channel distortion estimation signal 3203, and frequency offset estimation signal 3206 as input, eliminates frequency offset, channel distortion, and suchlike distortion, performs demodulation, and outputs channel B received digital signal 3007.

[0462]

By estimating channel distortion and frequency offset using channel A and channel B pilot symbols in this way, estimation precision is improved, and reception sensitivity characteristics are improved.

[0463]

The above description refers to the configuration in FIG. 32 in which a channel distortion estimation section and frequency offset estimation section are provided, but the present invention can be similarly implemented with a configuration in which only one or the other is provided.

[0464]

A transmitting apparatus and receiving apparatus are not limited to

the configurations in FIG. 2 and FIG. 34. Also, the use of multiplex frames and non-multiplexed frames with two channels and two antennas has been described as an example, but the present invention is not limited to this. For example, it is possible to implement the present invention similarly with multiplex frames using three channels and three antennas, and multiplex frames using two channels and two of three antennas. In this case, when using 3-channel multiplexing, channel distortion and frequency offset are estimated by using pilot symbols by three channels, whereby estimation precision is further improved. Also, the frame configurations are not limited to those in FIG. 26. Furthermore, an example has been described in which OFDM is used as the communication method, but it is possible to implement the present invention similarly with a multicarrier method, a spread spectrum communication method, or a single-carrier method. Moreover, a spread spectrum communication method may be used as the method for each carrier in a multicarrier system. Thus, it is possible to implement the present invention similarly with OFDM-CDM.

[0465]

Furthermore, there are also cases where one antenna is composed of a plurality of antennas.

[0466]

Thus, frequency offset and channel distortion is estimated by using channel A and channel B pilot symbols, whereby estimation precision is improved. Therefore, the effect of improving the reception sensitivity for channel A and channel B demodulation is obtained.

[0467]

(Embodiment 8)

In Embodiment 8, a description is given of a transmitting apparatus provided with one transmission baseband frequency source and one radio section frequency source, and a receiving apparatus provided with one reception baseband frequency source and one radio section frequency source, in a transmission method whereby modulated signals of a plurality of channels are transmitted from a plurality of antennas in the same frequency band.

[0468]

FIG. 36 shows an example of the configuration of a transmitting apparatus according to Embodiment 8. Parts in FIG. 36 identical to those in FIG. 2 are assigned the same reference numerals as in FIG. 2.

[0469]

Reference numeral 3601 is a frequency source 3601 for a transmission baseband signal, and outputs operating frequency signal 3602.

[0470]

Reference numeral 3603 is a frequency source for a radio section, and outputs operating frequency signal 3604.

[0471]

FIG. 37 shows an example of the configuration of a receiving apparatus according to Embodiment 8. Parts in FIG. 37 identical to those in FIG. 3 and FIG. 29 are assigned the same reference numerals as in FIG. 3 and FIG. 29.

[0472]

Reference numeral 3701 is a frequency source for a reception baseband, and outputs operating frequency signal 3702.

[0473]

Reference numeral 3703 is a frequency source for a radio section, and outputs operating frequency signal 3704.

[0474]

Using FIG. 36 and FIG. 37, explanations are given.

[0475]

The transmitting apparatus is explained.

[0476]

In FIG. 36, transmission baseband frequency source 3601 outputs operating frequency signal 3602 to serial/parallel conversion sections 202, 212 and discrete Fourier transform sections 204, 214.

[0477]

Then serial/parallel conversion sections 202 and 212, and discrete Fourier transform sections 204 and 214, perform signal processing in synchronization with operating frequency signal 3602.

[0478]

Similarly, radio section frequency source 3603 outputs operating frequency signal 3604 to radio sections 206, 216.

[0479]

Then radio sections 206 and 216 perform frequency conversion of post-discrete-Fourier-transform signals 205 and 215 in synchronization with operating frequency signal 3604, and output transmit signals 207 and 217.

[0480]

Thus, frequency sources can be reduced compared with a case in which a frequency source is provided individually for each antenna. Also, sharing frequency sources in the transmitting apparatus enables

channel A and channel B signal frequency synchronization and time synchronization to be performed easily in the receiving apparatus. This is because, since frequency sources are shared by channel A and channel B, individual synchronization is not necessary.

[0481]

The receiving apparatus at this time will now be described.

[0482]

Reception baseband frequency source 3701 outputs operating frequency signal 3702 to synchronization section 334.

[0483]

Synchronization section 334 compares operating frequency signal 3702 and the synchronization timing acquired by means of received quadrature baseband signals 304 and 314, and outputs timing signal 335 synchronized with the transmitting apparatus.

[0484]

Frequency source 3703 receives frequency offset estimation signal 333 as input, controls the frequency so as to be synchronized with the transmitting apparatus, and outputs operating frequency signal 3704 to radio sections 303, 313.

[0485]

Radio sections 303 and 314 perform frequency conversion of received signals 302 and 312 respectively based on input operating frequency signal 3704 and output received quadrature baseband signals 304 and 314. Thus, frequency sources can be reduced compared with a case in which a frequency source is provided individually for each antenna. Also, channel A and channel B signal frequency synchronization and time synchronization can be performed easily.

[0486]

A transmitting apparatus and receiving apparatus are not limited to the configurations in FIG. 36 and FIG. 37. Also, the use of multiplex frames and non-multiplexed frames with two channels and two antennas has been described as an example, but the present invention is not limited to this. For example, it is possible to implement the present invention similarly with multiplex frames using three channels and three antennas, and multiplex frames using two channels and two of three antennas. Also, an example has been described in which OFDM is used as the communication method, but it is possible to implement the present invention similarly with a multicarrier method, a spread spectrum communication method, or a single-carrier method. Moreover, a spread spectrum communication method may be used as the method for each carrier in a multicarrier system. Thus, it is possible to implement the present invention similarly with OFDM-CDM.

[0487]

Furthermore, there are also cases where one antenna is composed of a plurality of antennas.

[0488]

By using a transmitting apparatus provided with one transmission baseband frequency source and one radio section frequency source, and a receiving apparatus provided with one reception baseband frequency source and one radio section frequency source, in a transmission method whereby modulated signals of a plurality of channels are transmitted from a plurality of antennas in the same frequency band, as described above, frequency sources can be reduced compared with a

case in which a frequency source is provided individually for each antenna in the transmitting apparatus. Also, sharing frequency sources in the transmitting apparatus enables channel A and channel B signal frequency synchronization and time synchronization to be performed easily in the receiving apparatus.

[0489]

[Advantages]

As is clear from the above description, according to the present invention, by transmitting information of a high degree of importance by means of a method whereby one modulated signal of a communication system is transmitted by configuring in accordance with either a method whereby one modulated signal of a communication system is transmitted, or a method whereby a plurality of modulated signals of a communication system are multiplexed and transmitted, by frequency and time, an effect is achieved of enabling a communicating party communicating party to obtain information accurately. Also, by performing communication by frequency or time of a method whereby one modulated signal of a communication system is transmitted, and by frequency or time of a method whereby a plurality of modulated signals of a communication system are multiplexed and transmitted, according to the communication conditions, an effect is achieved of enabling information transmission speed and transmission quality to be made compatible.

[Brief Description of the Drawings]

[Fig. 1]

FIG. 1 is a drawing showing the frame configuration of the channel A and the channel B according to Embodiment 1 of the present

invention.

[Fig. 2]

FIG. 2 is a block diagram showing the configuration of a transmitting apparatus of Embodiment 1.

[Fig. 3]

FIG. 3 is a block diagram showing the configuration of a receiving apparatus of this embodiment.

[Fig. 4]

FIG. 4 is a drawing showing a positional relationship between a base station and terminals according to Embodiment 2 of the present invention.

[Fig. 5]

FIG. 5 is a block diagram showing the configuration of a terminal receiving apparatus of Embodiment 2.

[Fig. 6]

FIG. 6 is a block diagram showing the configuration of a terminal transmitting apparatus of Embodiment 2.

[Fig. 7]

FIG. 7 is a block diagram showing the configuration of a base station receiving apparatus of Embodiment 2.

[Fig. 8]

FIG. 8 is a drawing showing frame configurations according to Embodiment 3 of the present invention.

[Fig. 9]

FIG. 9 is a drawing showing a frame configuration according to Embodiment 3 of the present invention.

[Fig. 10]

FIG. 10 is a drawing showing the frequency arrangement according to Embodiment 3.

[Fig. 11]

FIG. 11 is a diagram showing the configuration of a transmitting apparatus according to Embodiment 3.

[Fig. 12]

FIG. 12 is a diagram showing the configuration of a receiving apparatus according to Embodiment 3.

[Fig. 13]

FIG. 13 is drawing showing an example of the configuration of a terminal receiving apparatus according to Embodiment 4 of the present invention.

[Fig. 14]

FIG. 14 is a drawing showing the configuration of a base station transmitting apparatus according to Embodiment 4.

[Fig. 15]

FIG. 15 is a drawing showing the frame configuration according to Embodiment 5.

[Fig. 16]

FIG. 16 is a drawing showing the configuration of a receiving apparatus according to Embodiment 5 of the present invention.

[Fig. 17]

FIG. 17 is a diagram showing the configuration of a terminal receiving apparatus according Embodiment 6 of the present invention.

[Fig. 18]

FIG. 18 is a diagram showing the frame configuration according to Embodiment 7 of the present invention.

[Fig. 19]

FIG. 19 is a diagram showing the configuration of a transmitting apparatus according to Embodiment 7 of the present invention.

[Fig. 20]

FIG. 20 is a diagram showing the configuration of a receiving apparatus according to Embodiment 7 of the present invention.

[Fig. 21]

FIG. 21 is a drawing showing an encoding method according to Embodiment 7.

[Fig. 22]

FIG. 22 is a drawing showing an encoding method according to Embodiment 7.

[Fig. 23]

FIG. 23 is a drawing showing an encoding method according to Embodiment 7.

[Fig. 24]

FIG. 24 is a drawing showing an encoding method according to Embodiment 7.

[Fig. 25]

FIG. 25 is a drawing showing an encoding method according to Embodiment 7.

[Fig. 26]

FIG. 26 is a drawing showing frame configurations of Embodiment 7.

[Fig. 27]

FIG. 27 is a drawing showing the configuration of pilot symbols of Embodiment 7.

[Fig. 28]

FIG. 28 is a drawing showing frame configurations according to Embodiment 7.

[Fig. 29]

FIG. 29 is a drawing showing the configuration of a receiving apparatus according to Embodiment 7.

[Fig. 30]

FIG. 30 is a diagram showing the configuration of a demodulation section of Embodiment 7.

[Fig. 31]

FIG. 31 is a diagram showing the configuration of a demodulation section of Embodiment 7.

[Fig. 32]

FIG. 32 is a diagram showing the configuration of a demodulation section of Embodiment 7.

[Fig. 33]

FIG. 33 is a diagram showing the configuration of a demodulation section of Embodiment 7.

[Fig. 34]

FIG. 34 is a diagram showing the configuration of a receiving apparatus according to Embodiment 7.

[Fig. 35]

FIG. 35 is a block diagram showing the configuration of a demodulation section of Embodiment 7.

[Fig. 36]

FIG. 36 is a block diagram showing the configuration of a transmitting apparatus according to Embodiment 8 of the present

invention.

[Fig. 37]

FIG. 37 is a block diagram showing the configuration of a receiving apparatus according to Embodiment 8 of the present invention.

[Fig. 38]

FIG. 38 is a diagram showing the configuration of a conventional radio transmitting apparatus and receiving apparatus.

[Reference Numerals]

101: guard symbol

102: information symbol

103: estimation symbol

104: control symbol

201: channel A transmit digital signal

202: channel A serial/parallel conversion section

203: channel A parallel signal

204: channel A inverse discrete Fourier transform section

205: channel A post-inverse-discrete-Fourier-transform signal

206: channel A radio section

207: channel A transmit signal

208: channel A power amplification section

209: channel A power-amplified transmit signal

210: channel A antenna

211: channel B transmit digital signal

212: channel B serial/parallel conversion section

213: channel B parallel signal

214: channel B inverse discrete Fourier transform section

215: channel B post-inverse-discrete-Fourier-transform signal

216: channel B radio section

217: channel B transmit signal

218: channel B power amplification section

219: channel B power-amplified transmit signal

220: channel B antenna

221: frame configuration signal generation section

222: frame configuration signal

223: control signal

301: antenna

302: received signal

303: radio section

304: received quadrature baseband signal

305: Fourier transform section

306: parallel signal

307: channel A channel distortion estimation section

308: channel A channel distortion parallel signal

309: channel B channel distortion estimation section

310: channel B channel distortion parallel signal

311: antenna

312: received signal

313: radio section

314: received quadrature baseband signal

315: Fourier transform section

316: parallel signal

317: channel A channel distortion estimation section

318: channel A channel distortion parallel signal

319: channel B channel distortion estimation section

320: channel B channel distortion parallel signal

321: signal processing section

322: carrier 7 through carrier 12 channel A parallel signal

323: carrier 7 through carrier 12 channel B parallel signal

324: carrier 7 through carrier 12 channel A demodulation section

325: carrier 7 through carrier 12 channel A received digital signal

326: carrier 7 through carrier 12 channel B demodulation section

327: carrier 7 through carrier 12 channel B received digital signal

328: selection section

329: selected parallel signal 329

330: carrier 1 through carrier 6 channel A demodulation section

331: carrier 1 through carrier 6 received digital signal

332: frequency offset estimation section

333: frequency offset estimation signal

334: synchronization section

335: timing signal

501: radio wave propagation environment estimation section

502: radio wave propagation environment estimation information

601: data

602: radio wave propagation environment estimation information

603: request information

604: information generation section

605: transmit digital signal

706: received digital signal

707: method determination section

708: control signal

1801: pilot symbol

1901: coding section

3002: channel distortion estimation section

3003: channel distortion estimation signal

3004: frequency offset estimation section

3005: frequency offset estimation signal

3006: information symbol demodulation section

[Name of Document] ABSTRACT

[Abstract]

[Object] To make data transmission speed and transmission quality compatible, by transmitting one modulated signal of the communication system in accordance with either a method whereby one modulated signal of a communication system is transmitted or a method whereby a plurality of modulated signals of a communication system are multiplexed and transmitted, based on frequency and time.

[Solving Means] By transmitting information including a frame whereby a plurality of modulated signals are transmitted from a plurality of antennas and a frame whereby a modulated signal is transmitted from one antenna, data transmission speed and transmission quality can be made compatible.

[Selected Figure] Fig. 1

[FIG. 1]

Base station transmit signal FRAME configuration

CHANNEL A FRAME configuration

FREQUENCY

TIME

Carrier 1, Carrier 2, Carrier 3, TERMINAL A

Carrier 4, Carrier 5, Carrier 6, TERMINAL B

Carrier 7, Carrier 8, Carrier 9, TERMINAL C

Carrier 10, Carrier 11, Carrier 12, TERMINAL D

CHANNEL B FRAME configuration

FREQUENCY

TIME

Carrier 1, Carrier 2, Carrier 3, TERMINAL A

Carrier 4, Carrier 5, Carrier 6, TERMINAL B

Carrier 7, Carrier 8, Carrier 9, TERMINAL C

Carrier 10, Carrier 11, Carrier 12, TERMINAL D

101: GUARD SYMBOL

102: INFORMATION SYMBOL

103: ESTIMATION SYMBOL

104: CONTROL SYMBOL

[FIG. 2]

channel A transmitting section

206 RADIO SECTION

channel B transmitting section

216 RADIO SECTION

221 FRAME CONFIGURATION SIGNAL GENERATION SECTION

[FIG. 3]

303 RADIO SECTION

307 channel A CHANNEL DISTORTION ESTIMATION SECTION

309 channel B CHANNEL DISTORTION ESTIMATION SECTION

313 RADIO SECTION

317 channel A CHANNEL DISTORTION ESTIMATION SECTION

319 channel B CHANNEL DISTORTION ESTIMATION SECTION

321 SIGNAL PROCESSING SECTION

324 carrier 7 through carrier 12 channel A DEMODULATION SECTION

326 carrier 7 through carrier 12 channel B DEMODULATION SECTION

328 SELECTION SECTION

330 carrier 1 through carrier 6 channel A DEMODULATION SECTION

332 FREQUENCY OFFSET ESTIMATION SECTION

334 SYNCHRONIZATION SECTION

[FIG. 4]

401 BASE STATION

402 TERMINAL A

403 TERMINAL B

404 TERMINAL C

405 TERMINAL D

[FIG. 5]

303 RADIO SECTION

307 channel A CHANNEL DISTORTION ESTIMATION SECTION

309 channel B CHANNEL DISTORTION ESTIMATION SECTION

313 RADIO SECTION

317 channel A CHANNEL DISTORTION ESTIMATION SECTION

319 channel B CHANNEL DISTORTION ESTIMATION SECTION

321 SIGNAL PROCESSING SECTION

324 carrier 7 through carrier 12 channel A DEMODULATION SECTION

326 carrier 7 through carrier 12 channel B DEMODULATION SECTION

328 SELECTION SECTION

330 carrier 1 through carrier 6 channel A DEMODULATION SECTION

332 FREQUENCY OFFSET ESTIMATION SECTION

334 SYNCHRONIZATION SECTION

501 RADIO WAVE PROPAGATION ENVIRONMENT ESTIMATION SECTION

[FIG. 6]

604 INFORMATION GENERATION SECTION

606 MODULATED SIGNAL GENERATION SECTION

608 RADIO SECTION

[FIG. 7]

703 RADIO SECTION

705 DEMODULATION SECTION

707 METHOD DETERMINATION SECTION

[FIG. 8]

Base station transmit signal FRAME configuration

FREQUENCY f1

CHANNEL A FRAME configuration

FREQUENCY, time

TIME

TERMINAL C, TERMINAL d

Carrier 1, Carrier 2, Carrier 3, TERMINAL C

Carrier 4, Carrier 5, Carrier 6, TERMINAL D

CHANNEL B FRAME configuration

FREQUENCY, time

TIME

TERMINAL C, TERMINAL d

Carrier 1, Carrier 2, Carrier 3, TERMINAL C

Carrier 4, Carrier 5, Carrier 6, TERMINAL D

102: INFORMATION SYMBOL

103: ESTIMATION SYMBOL

104: CONTROL SYMBOL

[FIG. 9]

Base station transmit signal FRAME configuration

FREQUENCY f2,

CHANNEL C FRAME configuration

FREQUENCY, TIME

TIME

TERMINAL A, TERMINAL B

CARRIER 1, CARRIER 2, CARRIER 3, TERMINAL A

CARRIER 4, CARRIER 5, CARRIER 6, TERMINAL B

102: INFORMATION SYMBOL

103: ESTIMATION SYMBOL

104: CONTROL SYMBOL

[FIG. 10]

POWER

FREQUENCY

[FIG. 11]

channel A transmitting section,

channel B transmitting section,

channel C transmitting section,

206 RADIO SECTION

216 RADIO SECTION

221 FRAME CONFIGURATION SIGNAL GENERATION SECTION

1106 RADIO SECTION

[FIG. 12]

1203 RADIO SECTION

1207 channel A CHANNEL DISTORTION ESTIMATION SECTION

1209 channel B CHANNEL DISTORTION ESTIMATION SECTION

1213 RADIO SECTION

1217 channel A CHANNEL DISTORTION ESTIMATION

SECTION

1219 channel B CHANNEL DISTORTION ESTIMATION SECTION

1221 SIGNAL PROCESSING SECTION

1224 channel A DEMODULATION SECTION

1226 channel B DEMODULATION SECTION

1228 FREQUENCY OFFSET ESTIMATION SECTION

1230 SYNCHRONIZATION SECTION

1234 RADIO SECTION

1238 CHANNEL DISTORTION ESTIMATION SECTION

1240 channel C DEMODULATION SECTION

1242 FREQUENCY OFFSET ESTIMATION SECTION

1244 SYNCHRONIZATION SECTION

[FIG. 13]

1203 RADIO SECTION

1207 channel A CHANNEL DISTORTION ESTIMATION SECTION

1209 channel B CHANNEL DISTORTION ESTIMATION SECTION

1213 RADIO SECTION

1217 channel A CHANNEL DISTORTION ESTIMATION SECTION

1219 channel B CHANNEL DISTORTION ESTIMATION SECTION

1221 SIGNAL PROCESSING SECTION

1224 channel A DEMODULATION SECTION

1226 channel B DEMODULATION SECTION

1228 FREQUENCY OFFSET ESTIMATION SECTION

1230 SYNCHRONIZATION SECTION

1234 RADIO SECTION

1238 CHANNEL DISTORTION ESTIMATION SECTION

1240 CHANNEL C DEMODULATION SECTION

1242 FREQUENCY OFFSET ESTIMATION SECTION

1244 SYNCHRONIZATION SECTION

1301 RADIO WAVE PROPAGATION ENVIRONMENT ESTIMATION SECTION

1303 RADIO WAVE PROPAGATION ENVIRONMENT ESTIMATION SECTION

[FIG. 14]

604 INFORMATION GENERATION SECTION

606 MODULATED SIGNAL GENERATION SECTION

608 RADIO SECTION

[FIG. 15]

Base station transmit signal frame configuration

CHANNEL A FRAME configuration

FREQUENCY, TIME, TIME, TIME

TERMINAL C, TERMINAL D, TERMINAL C, TERMINAL D

TERMINAL A, TERMINAL B

Carrier 1, carrier 2, carrier 3, TERMINAL A

Carrier 4, carrier 5, carrier 6, TERMINAL B

CHANNEL B FRAME configuration

FREQUENCY, TIME, TIME

TERMINAL C, TERMINAL D, TERMINAL C, TERMINAL D

Carrier 1, carrier 2, carrier 3

Carrier 4, carrier 5, carrier 6

101: GUARD SYMBOL

102: INFORMATION SYMBOL

103: ESTIMATION SYMBOL

104: CONTROL SYMBOL

[FIG. 16]

303 RADIO SECTION

307 channel A CHANNEL DISTORTION ESTIMATION SECTION

309 channel B CHANNEL DISTORTION ESTIMATION SECTION

313 RADIO SECTION

317 channel A CHANNEL DISTORTION ESTIMATION SECTION

319 channel B CHANNEL DISTORTION ESTIMATION SECTION

321 SIGNAL PROCESSING SECTION

1602 channel A DEMODULATION SECTION

1605 channel B DEMODULATION SECTION

328 SELECTION SECTION

1608 channel A DEMODULATION SECTION

332 FREQUENCY OFFSET ESTIMATION SECTION

334 SYNCHRONIZATION SECTION

[FIG. 17]

303 RADIO SECTION

307 channel A CHANNEL DISTORTION ESTIMATION SECTION

309 channel B CHANNEL DISTORTION ESTIMATION SECTION

313 RADIO SECTION

317 channel A CHANNEL DISTORTION ESTIMATION SECTION

319 channel B CHANNEL DISTORTION ESTIMATION SECTION

321 SIGNAL PROCESSING SECTION

1602 channel A DEMODULATION SECTION

1605 channel B DEMODULATION SECTION

328 SELECTION SECTION

1608 channel A DEMODULATION SECTION

332 FREQUENCY OFFSET ESTIMATION SECTION

334 SYNCHRONIZATION SECTION

1701 RADIO WAVE PROPAGATION ENVIRONMENT ESTIMATION SECTION

[FIG. 18]

Base station transmit signal frame configuration

CHANNEL A FRAME configuration

FREQUENCY, TIME, TIME

CARRIER 1, CARRIER 2, CARRIER 3

CARRIER 4, CARRIER 5, CARRIER 6

CHANNEL A, CHANNEL B

CHANNEL B FRAME configuration

FREQUENCY, TIME, TIME

CARRIER 1, CARRIER 2, CARRIER 3

CARRIER 4, CARRIER 5, CARRIER 6

101: GUARD SYMBOL

102: INFORMATION SYMBOL

103: ESTIMATION SYMBOL

104: CONTROL SYMBOL

1801: PILOT SYMBOL

[FIG. 19]

channel A transmitting section

channel B transmitting section

206 RADIO SECTION

216 RADIO SECTION

221 FRAME CONFIGURATION SIGNAL GENERATION SECTION

1901 CODING SECTION

[FIG. 20]

303 RADIO SECTION

307 channel A CHANNEL DISTORTION ESTIMATION SECTION

309 channel B CHANNEL DISTORTION ESTIMATION SECTION

313 RADIO SECTION

317 channel A CHANNEL DISTORTION ESTIMATION SECTION

319 channel B CHANNEL DISTORTION ESTIMATION SECTION

321 SIGNAL PROCESSING SECTION

2003 channel A DEMODULATION SECTION

2005 channel B DEMODULATION SECTION

332 FREQUENCY OFFSET ESTIMATION SECTION

334 SYNCHRONIZATION SECTION

[FIG. 21]

CHANNEL A CARRIER 1 TIME 4 (a)

CHANNEL B CARRIER 1 TIME 4 (b)

deferential encoding

[FIG. 22]

CHANNEL A CARRIER 1 TIME 4 (a)

CHANNEL B CARRIER 1 TIME 4 (b)

deferential encoding

[FIG. 23]

CHANNEL A CARRIER 1 TIME 4 (a)

CHANNEL B CARRIER 1 TIME 4 (b)

encoding

[FIG. 24]

CHANNEL A CARRIER 1 TIME 4 (a)

CHANNEL B CARRIER 1 TIME 4 (b)

encoding

[FIG. 26]

BASE STATION TRANSMIT SIGNAL FRAME CONFIGURATION

CHANNEL A FRAME CONFIGURATION

FREQUENCY, TIME, TIME

CARRIER 1, CARRIER 2, CARRIER 3

CARRIER 4, CARRIER 5, CARRIER 6

Channel A, channel b

CHANNEL B FRAME CONFIGURATION

CARRIER 1, CARRIER 2, CARRIER 3

CARRIER 4, CARRIER 5, CARRIER 6

101: GUARD SYMBOL

102: INFORMATION SYMBOL

103: ESTIMATION SYMBOL

104: CONTROL SYMBOL

1801: PILOT SYMBOL

[FIG. 27]

2701: KNOWN PILOT SYMBOL

2703: KNOWN BPSK PILOT SYMBOL

[FIG. 28]

BASE STATION TRANSMIT SIGNAL FRAME CONFIGURATION

CHANNEL A FRAME CONFIGURATION

FREQUENCY, TIME, TIME

CARRIER 1, CARRIER 2, CARRIER 3

CARRIER 4, CARRIER 5, CARRIER 6

Channel A, channel b

CHANNEL B FRAME CONFIGURATION

FREQUENCY, TIME, TIME

CARRIER 1, CARRIER 2, CARRIER 3

CARRIER 4, CARRIER 5, CARRIER 6

101: GUARD SYMBOL

102: INFORMATION SYMBOL

103: ESTIMATION SYMBOL

104: CONTROL SYMBOL

[FIG. 29]

303 RADIO SECTION

307 channel A CHANNEL DISTORTION ESTIMATION SECTION

309 channel B CHANNEL DISTORTION ESTIMATION SECTION

313 RADIO SECTION

317 channel A CHANNEL DISTORTION ESTIMATION SECTION

319 channel B CHANNEL DISTORTION ESTIMATION SECTION

321 SIGNAL PROCESSING SECTION

2903 channel A DEMODULATION SECTION

2905 channel B DEMODULATION SECTION

332 FREQUENCY OFFSET ESTIMATION SECTION

334 SYNCHRONIZATION SECTION

[FIG. 30]

3002 CHANNEL DISTORTION ESTIMATION SECTION

3004 FREQUENCY OFFSET ESTIMATION SECTION

3006 INFORMATION SYMBOL DEMODULATION SECTION

[FIG. 31]

3102 CHANNEL DISTORTION ESTIMATION SECTION

3104 FREQUENCY OFFSET ESTIMATION SECTION

3106 INFORMATION SYMBOL DEMODULATION SECTION

[FIG. 32]

3202 CHANNEL DISTORTION ESTIMATION SECTION

3204 FREQUENCY OFFSET ESTIMATION SECTION

3206 INFORMATION SYMBOL DEMODULATION SECTION

[FIG. 33]

3303 INFORMATION SYMBOL DEMODULATION SECTION

[FIG. 34]

303 RADIO SECTION

307 channel A CHANNEL DISTORTION ESTIMATION SECTION

309 channel B CHANNEL DISTORTION ESTIMATION SECTION

313 RADIO SECTION

317 channel A CHANNEL DISTORTION ESTIMATION SECTION

319 channel B CHANNEL DISTORTION ESTIMATION SECTION

321 SIGNAL PROCESSING SECTION

2903 channel A DEMODULATION SECTION

2905 channel B DEMODULATION SECTION

332 FREQUENCY OFFSET ESTIMATION SECTION

334 SYNCHRONIZATION SECTION

[FIG. 35]

3202 CHANNEL DISTORTION ESTIMATION SECTION

3204 FREQUENCY OFFSET ESTIMATION SECTION

3206 INFORMATION SYMBOL DEMODULATION SECTION

[FIG. 36]

CHANNEL A TRANSMITTING SECTION

206 RADIO SECTION

3601 FREQUENCY SOURCE

3603 FREQUENCY SOURCE

CHANNEL B TRANSMITTING SECTION

216 RADIO SECTION

221 FRAME CONFIGURATION SIGNAL GENERATION SECTION

[FIG. 37]

303 RADIO SECTION

307 CHANNEL A CHANNEL DISTORTION ESTIMATION SECTION

309 CHANNEL B CHANNEL DISTORTION ESTIMATION SECTION

313 RADIO SECTION

317 CHANNEL A CHANNEL DISTORTION ESTIMATION SECTION

319 CHANNEL B CHANNEL DISTORTION ESTIMATION SECTION

321 SIGNAL PROCESSING SECTION

2903 CHANNEL A DEMODULATION SECTION

2905 CHANNEL B DEMODULATION SECTION

332 FREQUENCY OFFSET ESTIMATION SECTION

334 SYNCHRONIZATION SECTION

3701 FREQUENCY SOURCE

3703 FREQUENCY SOURCE

[FIG. 38]

02 MODULATED SIGNAL GENERATION SECTION

04 RADIO SECTION

11 RADIO SECTION

13 DEMODULATION SECTION